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NATIONAL DAM SAFETY PROGRAM. MONROE CITY DAM (MO-10542), MISSIS--ETC(U)
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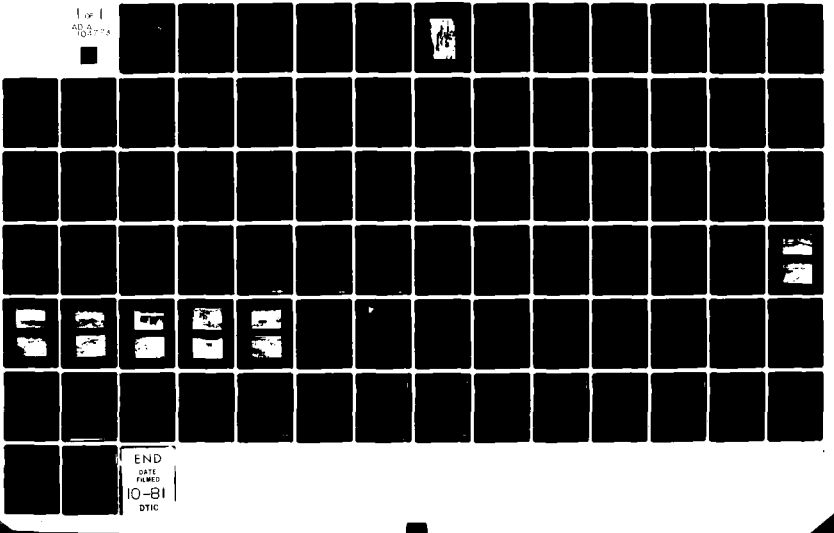


LEVEL

MISSISSIPPI - SALT - QUINCY RIVER BASIN

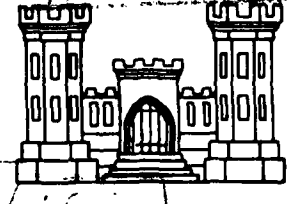
MONROE CITY DAM

RALLS COUNTY, MISSOURI

MO. 10542

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

Monroe City Dam (MO-10542), Mississippi
Salt - Quincy River Basin, Ralls County,
Missouri. Phase I Inspection Report.



PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JANUARY 1979

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Monroe City Dam (Mo. 10542),
Phase I Inspection Report

This report presents the results of field inspection and evaluation of Monroe City Dam (Mo. 10542). It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED
Chief, Engineering Division

26 FEB 1979
(Date)

APPROVED BY: SIGNED
Colonel, CE, District Engineer

26 FEB 1979
(Date)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Monroe City Dam, Missouri Inv. No. 10542
State Located:	Missouri
County Located:	Ralls
Stream:	Ely Creek
Date of Inspection:	September 30, 1978

Assessment of General Condition

Monroe City Dam No. Mo. 10542 was inspected using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of Federal and State agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. Three to four farmhouses with associated farm buildings, three County roads, and one unimproved road would be subjected to flooding with possible damage and/or destruction, and possible loss of life. Monroe City Dam is in the intermediate size classfication since it is more than 40 feet, but less than 100 feet high and impounds more than 1,000 acre-feet of water.

Our inspection and evaluation indicates that the spillway of Monroe City Dam meets the criteria set forth in the guidelines for a dam having the above size and hazard potential. Monroe City Dam is an intermediate size dam with a high hazard potential required by the guidelines to pass the Probable Maximum Flood without overtopping. It was determined that the spillway will pass 67 percent of the Probable Maximum Flood without overtopping the dam. Also, our evaluation indicates that the spillway will pass the 100-year flood; that is, a flood having a 1 percent chance of being equalled or exceeded in any given year.

The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

Other deficiencies noted by the inspection team were a need for a periodic inspection of the dam by a qualified professional engineer; lack of a maintenance schedule; seepage observed downstream of the toe of the embankment; small trees growing on the upstream embankment slope; vegetative growth in the outlet works and spillway discharge channels; and erosion gullies at the right abutment contact. The lack of seepage and stability analyses on record is also a deficiency that should be corrected.

It is recommended that the owner take action to correct or control the deficiencies described above.

Walter G. Shifrin, P.E.

MONROE CITY DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Monroe City Dam, I.D. No. 10542

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MONROE CITY DAM, Missouri Inv. No. 10542

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

The Dam Inspection Act, Public Law 92-367 of August, 1972, authorizes the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspections. Inspection for the Monroe City Dam was carried out under Contract DACW 43-78-C-0160 to the Department of the Army, St. Louis District, Corps of Engineers, by the engineering firms of Consoer, Townsend & Associates Ltd., and Engineering Consultants, Inc. (A Joint Venture), of St. Louis, Missouri.

b. Purpose of Inspection

The visual inspection of the Monroe City Dam was made on September 30, 1978. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

It should be noted that reference in this report to left or right abutments is as viewed looking downstream. Where left abutment or left side of the dam is used in this report, this also refers to north abutment or side, and right to the south abutment or side.

d. Evaluation Criteria

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams", Appendix D. These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 Description of the Project

a. Description of Dam and Appurtenances

The dam is a zoned embankment earthfill structure. The crest of the embankment has a width of 20 feet, constructed at an elevation of 680.0 feet above MSL. The length of the crest is 556 feet, and the maximum height of the embankment section is 48 feet above the minimum streambed elevation along the centerline of the dam. The upstream and downstream slopes are 1V to 3H from the crest to elevation 660.0, 1V to 10H from elevation 660.0 to 655.0, and 1V to 3H from elevation 655.0 to the ground surface.

The central zone of the embankment consists of semi-pervious random fill. This zone has a peak at elevation 672.0, with side slopes of 1V to 2H upstream and 1V to 1-1/2H downstream. The drawings show the finer material placed toward the upstream part of the zone. Upstream of the central zone, impervious fill was placed, and rock and earth random fill placed downstream of the central zone. On each side of the main embankment section are supporting berms constructed with random materials. A 3-foot thick drain, constructed with choker course, was placed parallel to the semi-impervious central zone on the downstream side. This drain has a top at elevation 672.0, and attempts to route the embankment seepage to a 4-foot thick horizontal rock drainage blanket with an 8-inch diameter corrugated metal pipe toe drain running nearly parallel to the centerline of the embankment. The C.M.P. extends for a length of 350 feet, and has a minimum invert elevation of 632.0 at station 6+40. From this point, a 10-inch corrugated metal pipe intersects the 8-inch toe drain, and routes the flow to the discharge channel of the outlet works pipe.

The upstream slope of the embankment section is provided with an 18-inch thick layer of rock riprap underlain by a 6-inch layer of gravel bedding. The riprap was composed of blocks of limestone with a maximum size of 4 feet in diameter. Most of the rock is 1 to 2 feet in diameter. The crest and downstream slope of the embankment is provided with a vegetative cover.

Bedrock at the site and within the vicinity is composed of limestones and shales of Mississippian age. The gently rolling hills of the area are mantled with residual clays, a weathered product of the bedrock. Alluvial deposits are encountered along the stream courses of the area.

The excavation for the spillway, about 250 feet north of the left abutment, exposes interbedded limestones, shales, and calcareous sandstones. The near horizontal lithologic units are generally massive; jointing is uncommon and random, and bedding planes are tight and spaced several feet apart. Borings and other data indicate bedrock is 5 feet below the ground surface in the abutments, and that through the channel section up to 13 feet of alluvium and/or residual soils overlie the bedrock.

Previous to fill placement the foundation was prepared by stripping surficial materials in the abutments and channel section to firm residual clays or bedrock units. A cut-off trench was also excavated into sound bedrock through the channel section of the dam parallel to and upstream of the dam axis. This trench had side walls inclined at 1V to 1-1/2H, and a base width of 30 feet.

The spillway is separated from the dam embankment and is located approximately 175 feet north of the right abutment contact. It is an open channel overflow structure with a concrete spillway control weir which has a base length of 166 feet. The approach channel to the control section is an open channel cut through rock. Length of this channel is approximately 160 feet from the reservoir to the control section. The spillway discharge channel is also a rock channel which runs in an easterly direction for about 175 feet, then turns south for about 300 feet. At this point it joins the outlet discharge channel and drains into Ely Creek.

A pump station is situated at the downstream toe of the dam which supplies raw water to the treatment facilities of Monroe City. The design data indicates that raw water reaches the pump station through a 10-inch cast iron branch line taken off of a 20-inch concrete pipe outlet which passes under the base of the dam embankment.

The 20-inch outlet pipe connects at its upstream end to an intake tower constructed of reinforced concrete. The tower extends up to the same elevation as the dam crest, and contains two control valves: a 10-inch butterfly valve for the service inlet port located at mid-depth of the reservoir, and a 20-inch butterfly valve for the low level outlet port located 7 feet above the reservoir bottom. The 10-inch valve is normally open while the 20-inch valve is normally closed. The stems connected to the valve operators extend up to the top deck where their ends are fitted with operating nuts. Both the service inlet and low level ports to the tower have trash protection screens. The top deck of the intake tower is accessible only by boat.

The extreme downstream section of the 20-inch outlet pipe is cast iron pipe with its end installed in a concrete headwall and closed off with a blind flange.

The reservoir at Monroe City Dam impounds 1,703 acre-feet of water from a tributary area of 7.29 square miles in the Ely Creek Basin.

b. Location

The Monroe City Dam is located on Ely Creek, a tributary of the Salt River, Ralls County, Missouri. The nearest downstream community is Hatch, Missouri, approximately 2 miles from the lake. Immediately downstream is the Route J bridge which crosses Ely Creek.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams", by the U.S. Department of the Army, Office of the Chief Engineer, the dam is classified in the dam size category as being "Intermediate" since its storage is more than 1,000 acre-feet, but less than 50,000 acre-feet. The dam is also classifed as "Intermediate" in dam size category because its height is more than 40 feet, but less than 100 feet. The overall size classification is, accordingly, "Intermediate" in size.

d. Hazard Classification

The dam has been classified as having "High" hazard potential in the National Inventory of Dams, on the basis that in the event of failure of the dam or its appurtenances, excessive damage could occur to downstream property, together

with the possibility of the loss of life. Our findings concur with the classification. The estimated damage zone extends six miles downstream of the dam. Within the damage zone are three to four farmhouses and associated buildings, three county roads and one unimproved road. The town of Hatch, which is two miles downstream of the dam, is also within the estimated damage zone.

e. Ownership

Monroe City Dam is owned by Monroe City, Ralls County, Missouri.

f. Purpose of Dam

The main purpose of the dam is to impound water for use in a water supply system for Monroe City, and also for recreation.

g. Design and Construction History

The dam was designed by Larkin and Associates of Kansas City, Missouri in 1964. The dam was constructed in 1967 by Smith & Wickum Construction of Salem, Missouri. No reconstruction has been performed on the dam or appurtenant structures since the original construction.

h. Normal Operational Procedures

At this time, the dam is used to impound water for recreational purposes, with the intent of using the reservoir for water supply in the future. The reservoir level is controlled by rainfall, runoff, and evaporation, and is kept close to full most of the time.

1.3 Pertinent Data

a. Drainage Area (acres)	4,666
b. Discharge at Damsite	
Estimated experienced maximum flood (cfs):	8,000
Estimated ungated spillway capacity at maximum pool elevation (cfs):	17,000
c. Elevation (Feet above MSL)	
Top of dam:	680.0
Spillway crest:	670.0
Minimum streambed elevation at centerline of dam:	632.0
Maximum tailwater:	Unknown
d. Reservoir	
Length of maximum pool (feet):	8,160
e. Storage (Acre-Feet)	
Top of dam:	3,248
Spillway crest:	1,703
f. Reservoir Surface (Acres)	
Top of dam:	178
Spillway crest:	131
g. Dam	
Type:	Zoned Embankment
Length:	556 feet
Height (maximum):	48 feet
Top width:	20 feet

Side slopes:	
Downstream	1V to 3H to El. 660.0, 1V to 10H to El. 655.0 and 1V to 3H to ground surface
Upstream	Same
Zoning:	Central core of semi-impervious random fill, upstream zone of impervious fill, downstream zone of rock and earth random fill
Impervious core:	Impervious zone is upstream fill, central core is semi-impervious
Cutoff:	Core trench with 30-foot bottom width and 1V to 1-1/2H side slopes
Grout curtain:	None

h. Diversion and Regulating Tunnel — None

i. Spillway

Type:	Uncontrolled
Length of weir (feet):	166
Crest Elevation (feet above MSL):	670.0

j. Regulating Outlets

Type:	20-inch diameter reinforced concrete pipe with a 10-inch cast iron pipe branch line
Length:	340 feet
Closure:	Blind flange at downstream end
Maximum Capacity:	40 cfs

SECTION 2: ENGINEERING DATA

2.1 Design

Original design drawings are available for the dam and appurtenant structures. The drawings were made in 1964, and are given as plates in this report. The drawings are available from City of Monroe officials, and from the design engineers, Larkin and Associates, Kansas City, Missouri. Miscellaneous spillway design calculations are also available.

2.2 Construction

The dam was constructed in 1967 by Smith & Wickum Construction of Salem, Missouri. Complete specifications for construction of the project are available; however, no reports were made during the construction period, nor were as-built drawings made for the dam and appurtenant structures. No reconstruction has been done at the damsite.

2.3 Operation

No operation records are available for Monroe City Dam.

2.4 Evaluation

a. Availability

Available engineering data includes original design drawings, contract specifications, and some hydrologic calculations. Included on the drawings and in the specifications are logs of test holes drilled in the vicinity of the damsite and in the borrow areas.

b. Adequacy

The engineering data available is adequate to aid in evaluating the hydraulic and hydrologic capabilities and stability of the dam for Phase I investigations.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity

The dam and appurtenant structures appears to have been constructed in accordance with the available design drawings, with the exception of the spillway weir structure.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

A visual inspection of Monroe City Dam was made on September 30, 1978. The following persons were present during the inspection:

Name	Affiliation	Disciplines
Yin Au-Yeung	Engineering Consultants, Inc.	Project Engineer, Hydraulics and Hydrology
David Bramwell	Engineering Consultants, Inc.	Geology
Jon Diebel	Engineering Consultants, Inc.	Soils
John Ismert	Engineering Consultants, Inc.	Mechanical
Kevin Blume	Consoer, Townsend & Assoc., Ltd.	Civil & Structural

Specific observations are discussed below.

b. Dam

The crest of the embankment has a heavy vegetative cover, and is in generally good condition. It appears that posts were recently placed on the right side of the crest to prevent vehicular traffic on the crest.

The rock riprap on the upstream slope of the embankment is thin, permitting vegetation to grow on the slope. The vegetation did not appear to be a problem at the present time, however, some trees were starting to grow, and

stumps were present from trees which had been growing on the slope and cut previously. The riprap, although allowing some vegetation to grow, is adequately protecting the embankment slope from sloughing and erosion due to wave action.

Sloughing and erosion of embankment materials was not present to any degree on the slope. Rodent activity was also not observed on the embankment.

The downstream embankment slope is well vegetated. Some very small erosion gullies were present at the right abutment contact, and rock checks had been placed at the downstream end of the gullies. The erosion had not progressed to an advanced degree at this time.

Seepage was present immediately downstream of the toe of the embankment to the left of the pump station. The seepage was confined to an area approximately 20 feet by 100 feet, running perpendicular to the dam centerline, with water flowing at a small rate from the area into the outlet works discharge channel. This seepage location exhibited cattails, ponding water, and tire tracks from traffic in the boggy area. The seepage location was formerly used for parking adjacent to the pump station. The outlet end of the toe drain pipe was found to be one-half full of debris and mud.

c. Appurtenant Structures

(1) Spillway

The approach channel, control section, and discharge channel of the spillway are well defined and in adequate condition with exception of the heavy vegetative growth in the area upstream of the control section for about 100 feet, and the very dense tree growth for about 150 feet immediately downstream of the control section. This vegetation in the spillway area would obstruct discharge through the spillway.

(2) Outlet Works

Observations were made of the top deck and upper portion of the intake tower, the downstream end and headwall of the outlet pipe and the pump station exterior.

The observed portions of concrete in the intake tower and headwall were seen to be in good, sound condition. The closure flange on the outlet pipe is firmly bolted in place, but has a light coating of rust. The pump station was locked and its interior could not be inspected.

The discharge channel was heavily vegetated and included some tree growth.

d. Reservoir Area

The water surface elevation was 669.7 feet above MSL at the time of inspection.

No wave wash, excessive erosion, or slides were observed along the reservoir rim. The reservoir rim is moderately sloping with dense woods and forest at the reservoir shore and at the higher elevations in the watershed.

e. Downstream Channel

The channel immediately downstream from the confluence of the spillway discharge channel and the outlet discharge channel is trapezoidal in shape and well defined with a rock streambed. The channel has a bottom width of approximately 25 feet at the narrowest point, and side slopes of approximately 1V to 2.5H on the left bank and 1V to 4H on the right bank. There is no sign of erosion, slope sloughing or accumulation of debris.

3.2 Evaluation

The following items were observed which could affect the safety of the dam, or which will require maintenance within a reasonable period of time.

1. The large seepage area downstream of the toe of the embankment to the left of the pump station.

2. The erosion gullies at the right abutment contact.

3. The small trees growing on the upstream embankment slopes and stumps indicating that large trees formerly had grown on the slope.

4. The heavy vegetation in the outlet works discharge channel.

5. The vegetative growth in the spillway channel.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The Monroe City Dam impounds water for recreational use and water supply. However, at this time Monroe City is using the lake purely for recreational purposes, even though the water supply pumping facilities have been installed at the damsite. The water level is essentially controlled by rainfall, runoff, and evaporation. Water level measurements are taken periodically, but daily records are not kept at this time.

4.2 Maintenance of Dam

The dam is maintained by the water superintendent of Monroe City, Missouri. Maintenance of the dam and appurtenant structures appeared to be satisfactory. Evidence of maintenance being performed includes cutting of the grass on the dam crest and downstream slope, along with protection of the dam crest from vehicular traffic. Small trees were observed to be growing on the upstream slope all along the dam. In addition, the channels for the spillway and outlet works are generally obstructed with heavy vegetative growth, including small trees.

4.3 Maintenance of Operating Facilities

Since the reservoir is not yet being used for water supply, the inlet structure and pump house have not required any regular maintenance as yet. The 20-inch butterfly valve and the 10-inch butterfly valve at the control tower have not been operated

in some time, but it is believed that they are in good condition. The same holds true for the gate valve located at the outlet facility.

4.4 Description of Any Warning System in Effect

The inspection team is not aware of any existing warning system for this dam.

4.5 Evaluation

The operation and maintenance for this dam appears to be satisfactory. Very little operation is required for the reservoir, although the butterfly valves should be operated periodically to insure satisfactory performance. Maintenance for the dam and appurtenant structures seems to be adequate, with the exception of a need to remove the small trees growing on the upstream embankment slope, and clear the vegetation from the spillway and outlet works discharge channel.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

Monroe City Lake has a watershed of approximately 4,666 acres. Land gradients in the upper portion of the watershed average roughly 2 percent, and steepen to about 4 percent around the reservoir. The lake is located on Ely Creek, which is a tributary of Salt River.

Elevations within the watershed range from approximately 620 feet above MSL at the damsite to over 730 feet above MSL in the upper portion of the watershed.

The watershed is approximately 30 percent covered by thick forest, with the remainder being covered by thick grass and brush. A drainage map showing the watershed area is included in Appendix B.

Evaluation of the hydraulic and hydrologic features of Monroe City Dam was based on criteria set forth in the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, and additional guidance provided by the St. Louis District of the Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Preciptation (PMP) using the methods outlined in the U.S. Weather Bureau Publication, Hydrometerological Report No. 33. The probable maximum storm duration was set at 24 hours, and storm rainfall distribution was based on criteria given in EM 1110-2-1411 (Standard Project Storm). The SCS triangular

hydrograph, transformed to a curvilinear hydrograph, was adopted for developing the unit hydrograph. The derived unit hydrograph is presented in Appendix B.

Initial and infiltration loss rates were applied to the PMP to obtain rainfall excesses. The rainfall excesses were then applied to the unit hydrograph to obtain the PMF hydrograph, utilizing the Corps of Engineers' computer program HEC-1 (Dam Safety Version), which was prepared specifically for dam safety analysis. The computed peak discharge of the PMF and one-half of the PMF are 29,279 cfs and 14,640 cfs, respectively.

Both the PMF and one-half of the PMF inflow hydrographs were routed through the reservoir by the Modified Puls Method, also utilizing the HEC-1 (Dam Safety Version) computer program. The peak outflow discharges for the PMF and one-half of the PMF are 26,557 cfs and 12,243 cfs, respectively. Only the PMF, when routed through the reservoir, resulted in overtopping of the dam.

The stage-outflow relation for the spillway was prepared from field notes and sketches. The reservoir stage-capacity data were based on the U.S.G.S. quadrangle topographic maps in combination with data given in the National Dam Safety Inventory Table. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway and overtop rating curve assumed that the dam remains intact during routing. The spillway and overtop rating curve and the reservoir capacity curve are also presented in Appendix B.

b. Experience Data

No records of reservoir stage or spillway discharge are maintained for this site. However, according to interviews with local residents, the maximum reservoir level was never higher than the crest of the embankment.

c. Visual Observations

With the exception of vegetative growth in the spillway channel, the spillway is in adequate condition. Since the spillway and exit channels are located away from the dam embankment, and the downstream discharge channel is far away from the downstream toe of the dam, spillway releases will not endanger the integrity of the dam.

d. Overtopping Potential

As indicated in Section 5.1-a., only the Probable Maximum Flood when routed through the reservoir, resulted in overtopping of the dam. The PMF overtopped the dam crest by 1.91 feet. The total duration of embankment overflow is 2.75 hours. The spillway of the Monroe City Dam is capable of passing a flood equal to approximately 67 percent of the PMF just before overtopping of the dam. The 67 percent PMF has a frequency occurrence less than a 100-year frequency flood. Since the PMF is the Spillway Design Flood (SDF) for Monroe City Dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps, the spillway capacity of the dam is considered "Inadequate".

The effect from rupture of the dam could extend approximately six miles downstream of the dam. There are three to four farmhouses with associated farm buildings, three county roads, and one unimproved road within this six miles of floodplain area. The Highway "J" Bridge is one-quarter mile downstream, and will carry significantly increase traffic to the completed Cannon Reservoir. The town of Hatch, located downstream of the dam, is within the estimated 6-mile damage zone.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There were no signs of settlement or distress observed on the embankment or foundation during the visual inspection. The crest and downstream slope are well protected by either riprap or vegetation. Trees allowed to grow on the upstream embankment slope will eventually become a hazard to the safety of the embankment. The erosion gullies at the right abutment contact are not felt to present a hazard to the embankment at this time, but should be repaired to prevent further erosion.

The major potential problem to the structural stability of the embankment is the seepage located downstream of the toe of the embankment. This seepage has saturated a large area of the foundation, and could additionally be affecting embankment materials. One possibility for the seepage is the toe drain placed during construction in the embankment section. The outlet end of the toe drain appeared to be plugged with debris, and it is possible that the blocked pipe has a leak which forces the drain to discharge the collected flow into the foundation materials. The location of the seepage area is in the vicinity of the proposed toe drain alignment. It is recommended that the toe drain be located and uncovered to confirm its satisfactory performance. If the toe drain is not found to be the cause of the seepage, further study should be performed to evaluate the potential effects of the seepage on the stability of the embankment and foundation.

No problems were observed with the spillway or outlet works which would cause an adverse affect on the structural stability of the dam or appurtenant structures.

b. Design and Construction Data

Included on the drawings and in the specifications are logs of test holes drilled in the vicinty of the damsite and in the borrow areas. The specifications contain detailed requirements for proper compaction of the embankment fill and segregation of the various materials used in the embankment section. No reports of the construction period are available.

c. Operating Records

No operating records are available relating to the stability of the dam or appurtenant structures. Water levels have not been recorded, however, the pool was only 4 inches below the spillway crest on the day of inspection, and is assumed to be close to full at all times. The only operation facility at the dam is a water supply intake and appurtenant piping.

d. Post Construction Changes

No post construction changes exists which will affect the structural stability of the dam.

e. Seismic Stability

In general projects located in Seismic Zones 0, 1 and 2 can be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Monroe City Dam is located

in Seismic Zone 1. A detailed seismic analysis is not felt to be necessary for this embankment.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team.

It is also important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that an unsafe condition could be detected.

a. Safety

Monroe City Dam was found to be capable of satisfactorily passing a flood equal to 67 percent of the PMF, which has a frequency occurrence less than the one percent chance flood. The spillway capacity should be increased to pass 100 percent of the PMF.

The overall physical condition of the dam and appurtenant structures is good, however, the seepage area downstream of the embankment toe to the left of the pump station requires further study to determine its cause and potential effect on the safety of the dam embankment.

Several other items were observed during the visual inspection which will require repairs or maintenance within a reasonable period of time. These items include:

1. The small trees beginning to grow on the upstream embankment slope.

2. The heavy vegetative growth in the outlet works discharge channel.

3. The vegetative growth in the spillway channel.

4. Repair erosion gullies to prevent further erosion.

b. Adequacy of Information

Information concerning operation and maintenance of the dam and appurtenant structures is somewhat lacking. It is recommended that the following programs be initiated to help alleviate this problem:

1. Periodic inspection of the dam by a professional engineer experienced in the design and construction of earthen dams should be made and this inspection report made a matter of record.

2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

3. Perform seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams".

c. Urgency

The remedial measures recommended in Paragraph 7.2 should be accomplished within a reasonable period of time.

d. Necessity for Phase II Inspection

Based on results of the Phase I inspection, a Phase II inspection is not felt to be necessary.

7.2 Remedial Measures

a. A study should be performed to determine the cause and potential effect of the seepage observed downstream of the toe of the embankment.

b. Increase the spillway capacity to pass 100 percent of the PMF.

c. O & M Maintenance Procedures

The owner should initiate the following programs:

1. Periodic inspection of the dam by a professional engineer experienced in the design and construction of earthen dams.

2. Set up a maintenance schedule and log all visits to the dam for operation, repairs and maintenance.

3. Cut the small trees on the upstream embankment slope, and prevent future growth.

4. Clear the vegetative growth from the outlet works discharge channel.

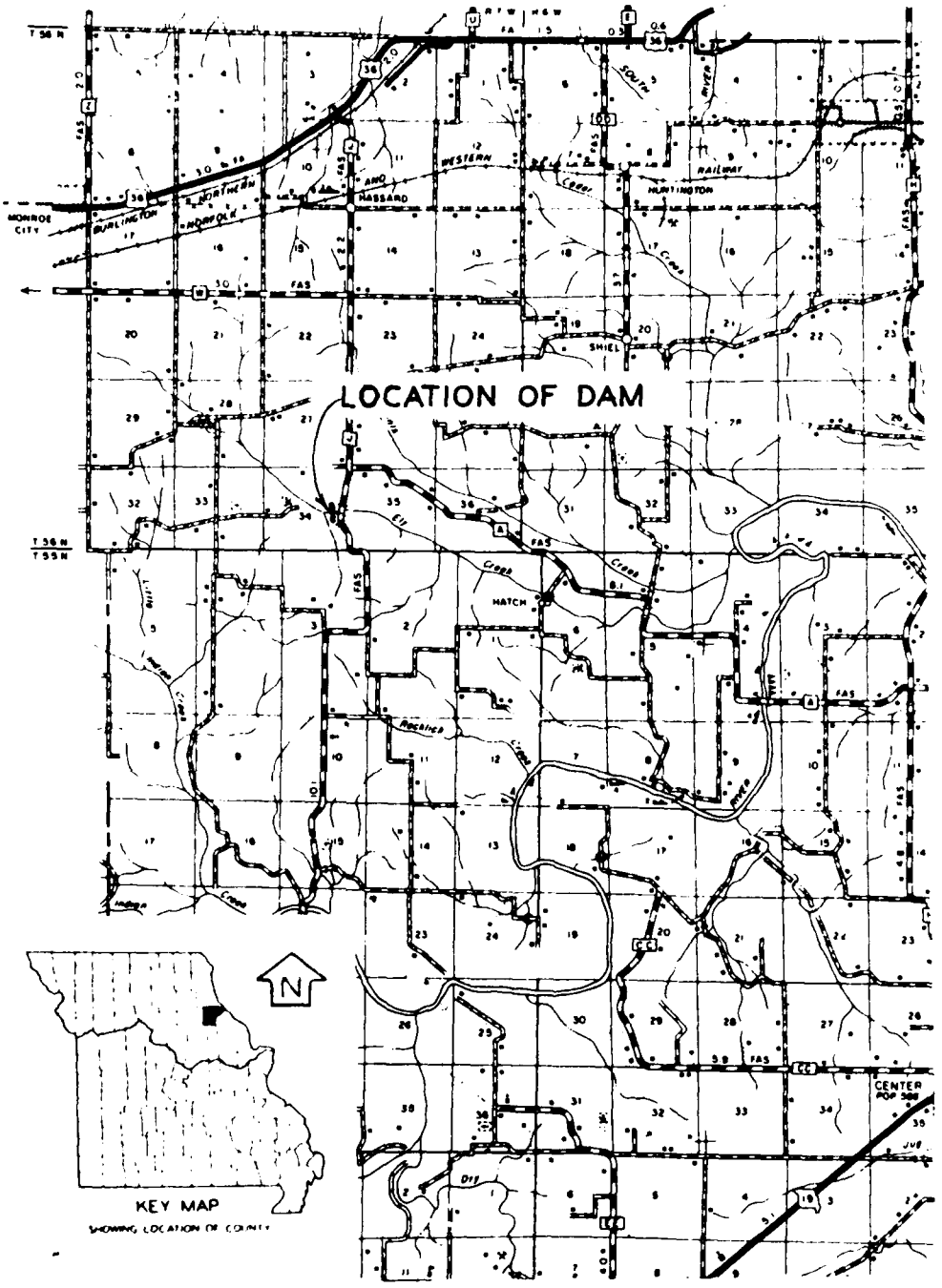
5. Clear the vegetative growth from the spillway channel.

6. Perform a trial operation of the butterfly valves periodically.

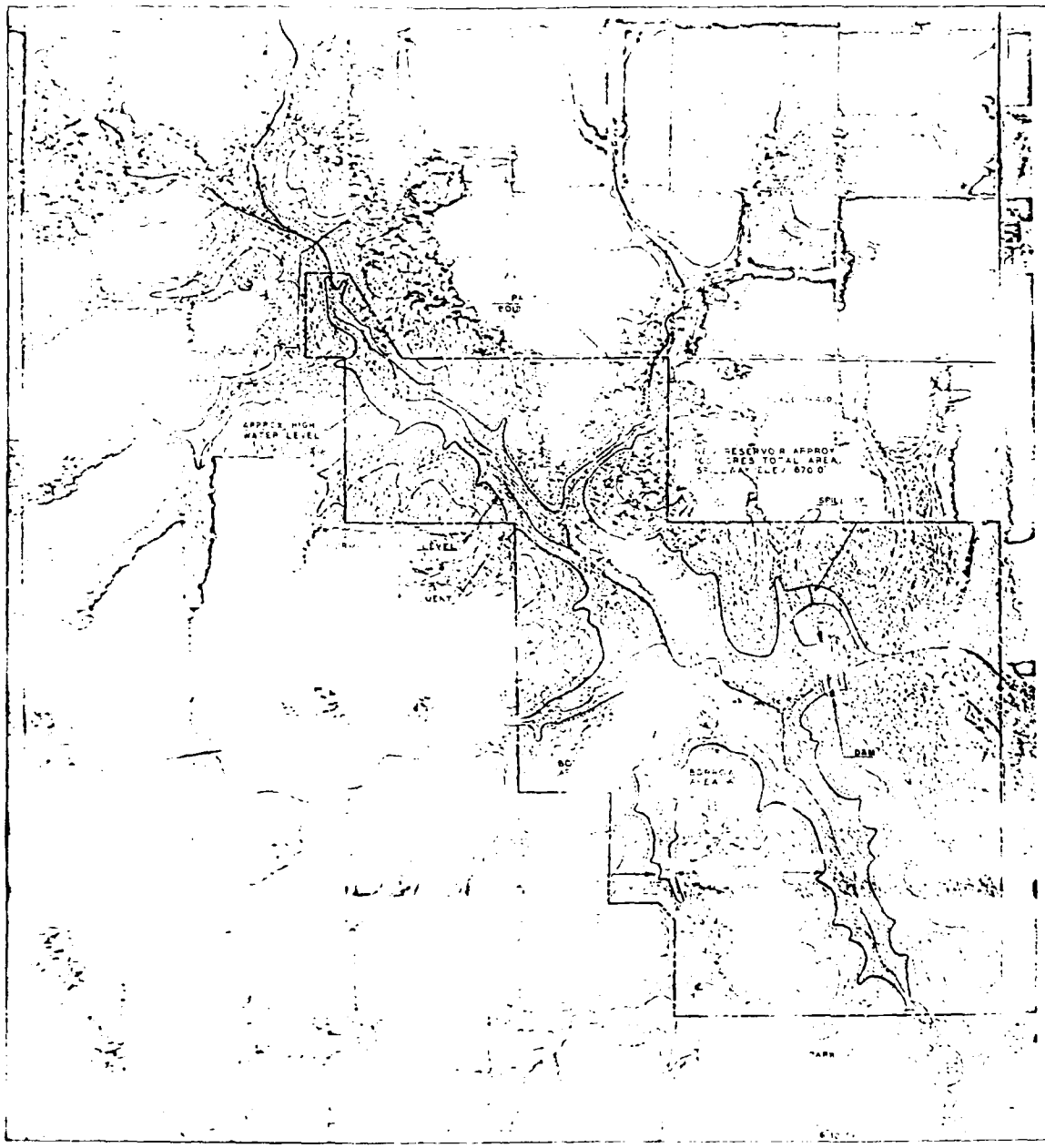
7. Repair erosion gullies to prevent further erosion.

8. Seepage and stability analysess should be performed by a professional engineer experienced in the design and construction of dams.

PLATES



LOCATION MAP
MONROE CITY DAM
RALLS COUNTY, MISSOURI



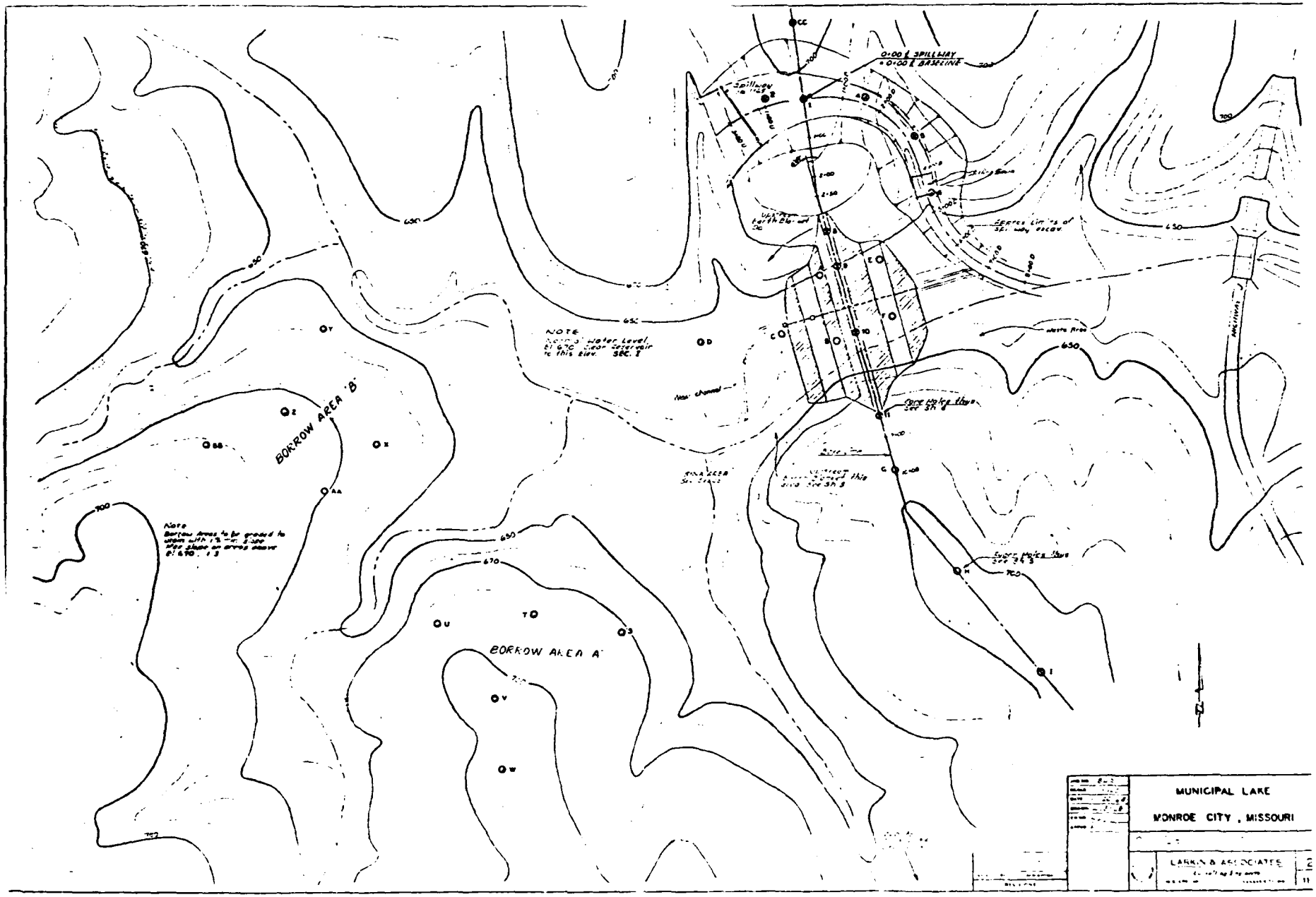
MUNICIPAL LAKE AND RECREATIONAL PARK

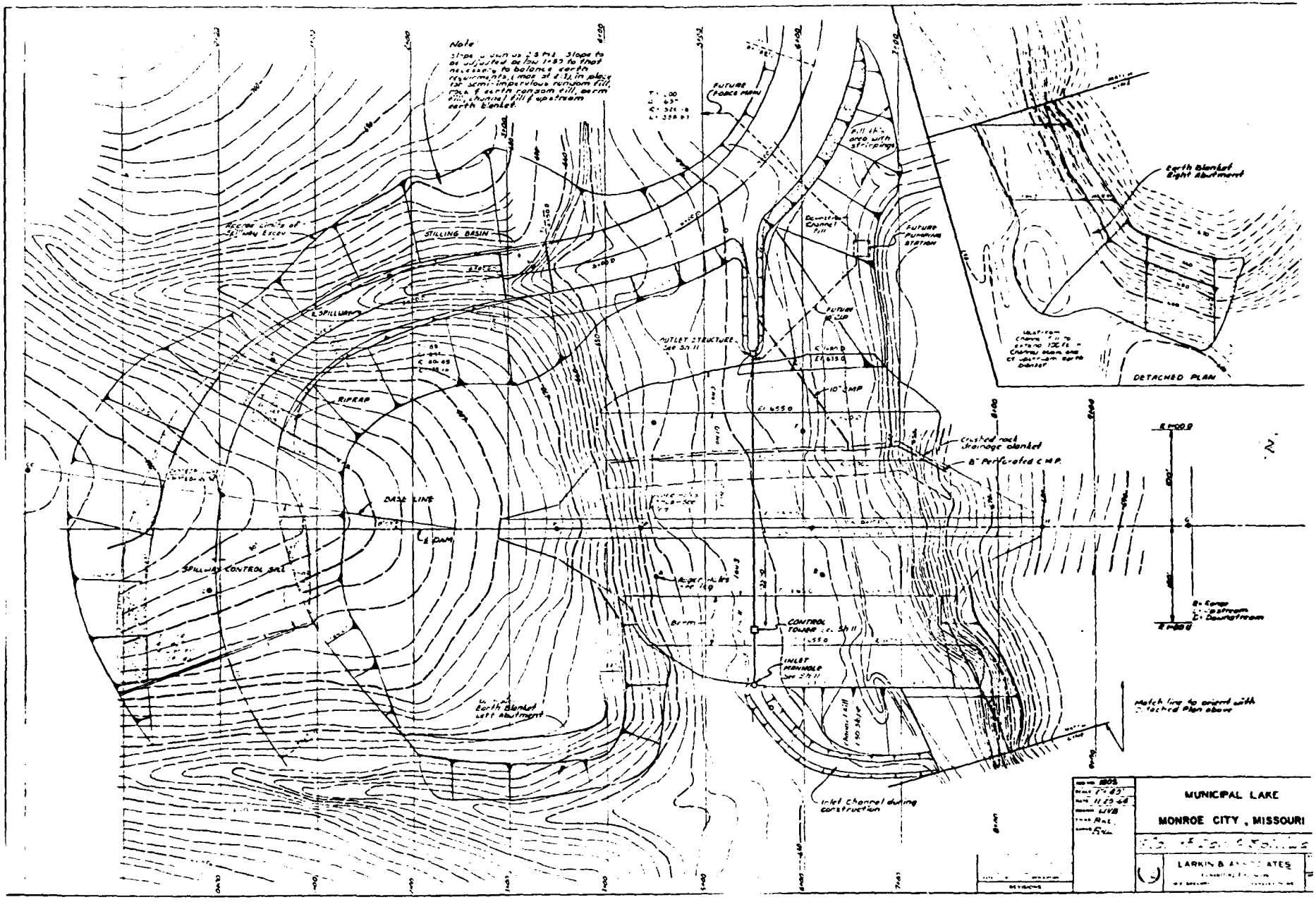
MONROE CITY, MISSOURI

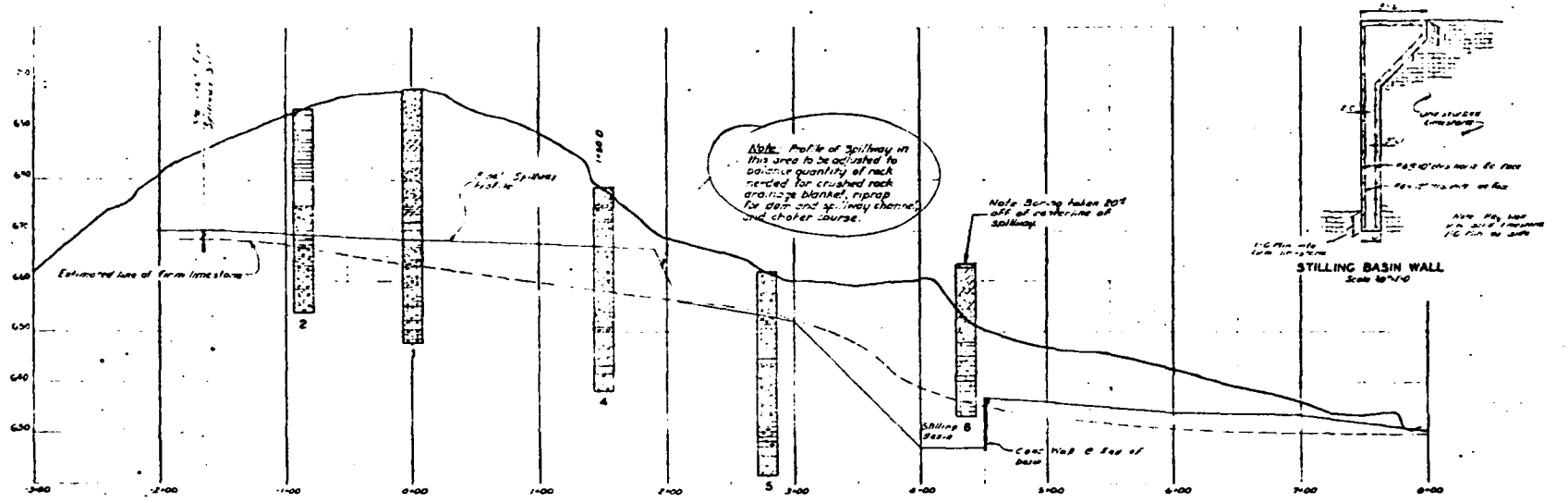
LIST OF DRAWINGS

1. COVER & AERIAL PHOTO
2. SPILLWAY & DAM BORROW AREAS
3. PLAN OF DAM & SPILLWAY
4. PROFILES OF DAM & SPILLWAY
5. OVERBURDEN AUGER HOLES
6. CROSS SECTIONS - DAM
7. " " "
8. CROSS SECTIONS - SPILLWAY
9. " " "
10. SPILLWAY STRUCTURES & CUTOFF TRENCH
11. MISC DETAILS

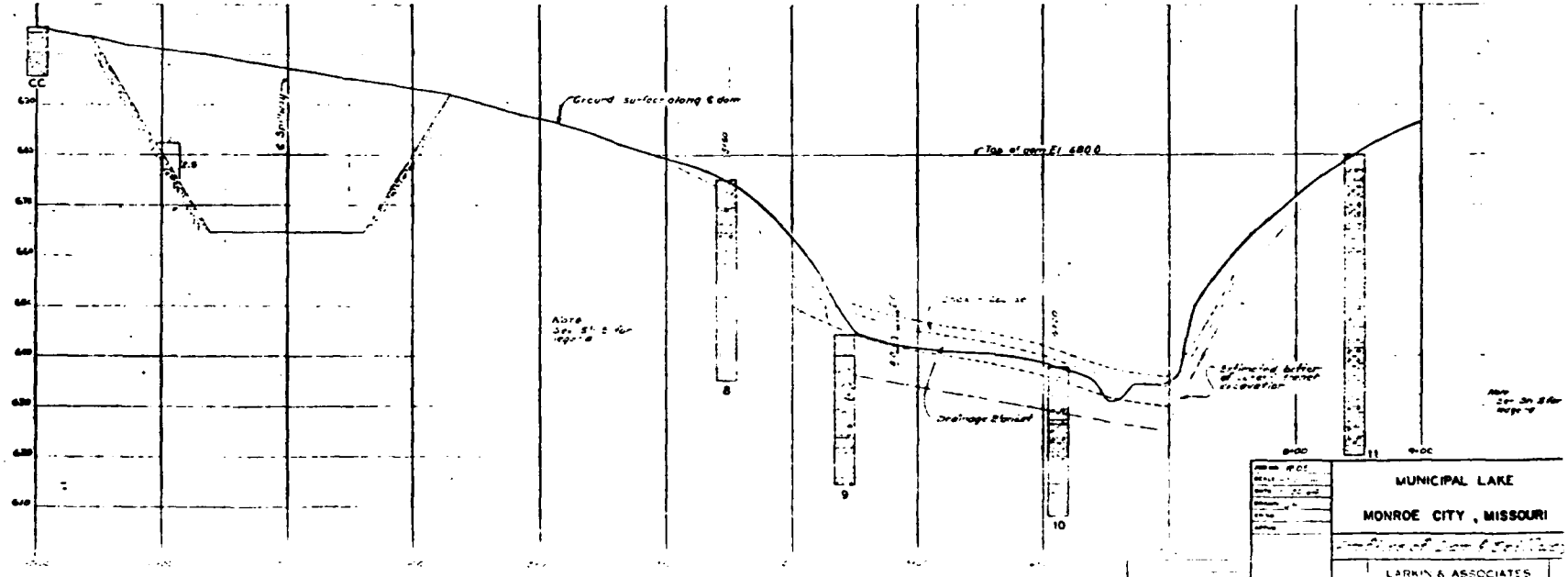
LARKIN & ASSOCIATES
CONSULTING ENGINEERS
KANSAS CITY, MO


0+00 ℄ SPILLWAY
0+00 ℄ BASELINE
BORROW AREA 'B'
BORROW AREA 'A'
NOTE
MUNICIPAL LAKE
MONROE CITY, MISSOURI
LARKIN & ASSOCIATES


Note
STILLING BASIN
SPILLWAY
RIPRAP
BASE LINE
E. DAM
SPILLWAY CONTROL SILL
OUTLET STRUCTURE
CONTROL TOWER
INLET MANHOLE
FUTURE PUMPING STATION
Crushed rock drainage blanket
8" Perforated C.M.P.
Earth Blanket Left Abutment
Earth Blanket Right Abutment
DETACHED PLAN
Inlet Channel during construction
MUNICIPAL LAKE
MONROE CITY, MISSOURI
LARKIN & ASSOCIATES



PROFILE OF SPILLWAY

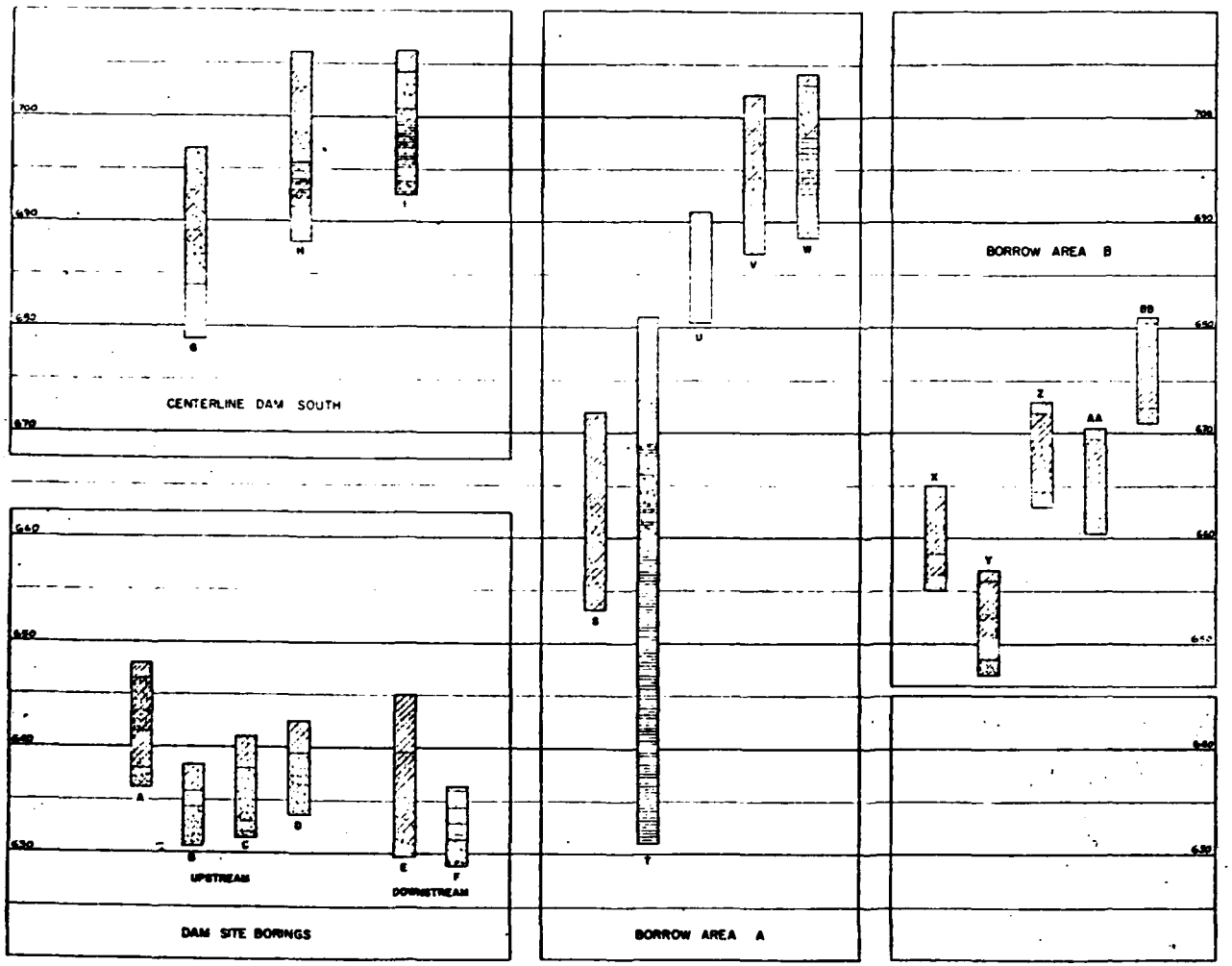


PROFILE OF DAM

MUNICIPAL LAKE

MONROE CITY, MISSOURI

LARKIN & ASSOCIATES
Consulting Engineers



LEGEND

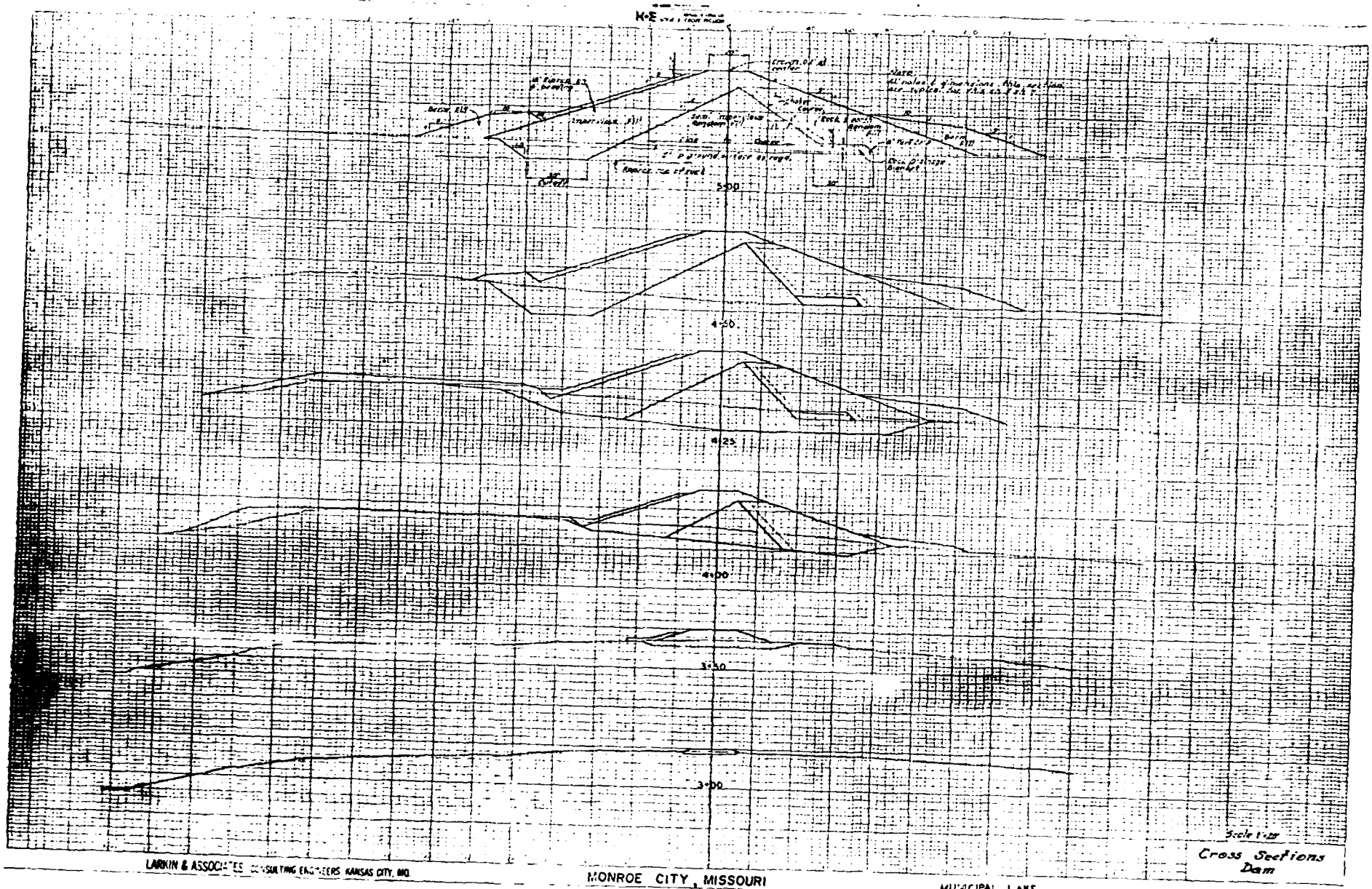
- TOPSOIL
- CLAY — RED, BROWN, GRAY OR YELLOW MOIST, STIFF, DENSE OR VERY DENSE
- SAND — FINE, MEDIUM, OR DENSE
- GRAVEL
- BOULDERS — MOSTLY CHERT
- SHALE — GRAY TO BROWN - WEATHERED
- SILT
- SANDSTONE — YELLOW TO BROWN, BROKEN - WEATHERED
- CHERTY LIMESTONE
- LIMESTONE

MUNICIPAL LAKE

MONROE CITY, MISSOURI

Core boring Auger hole

LARKIN & ASSOCIATES

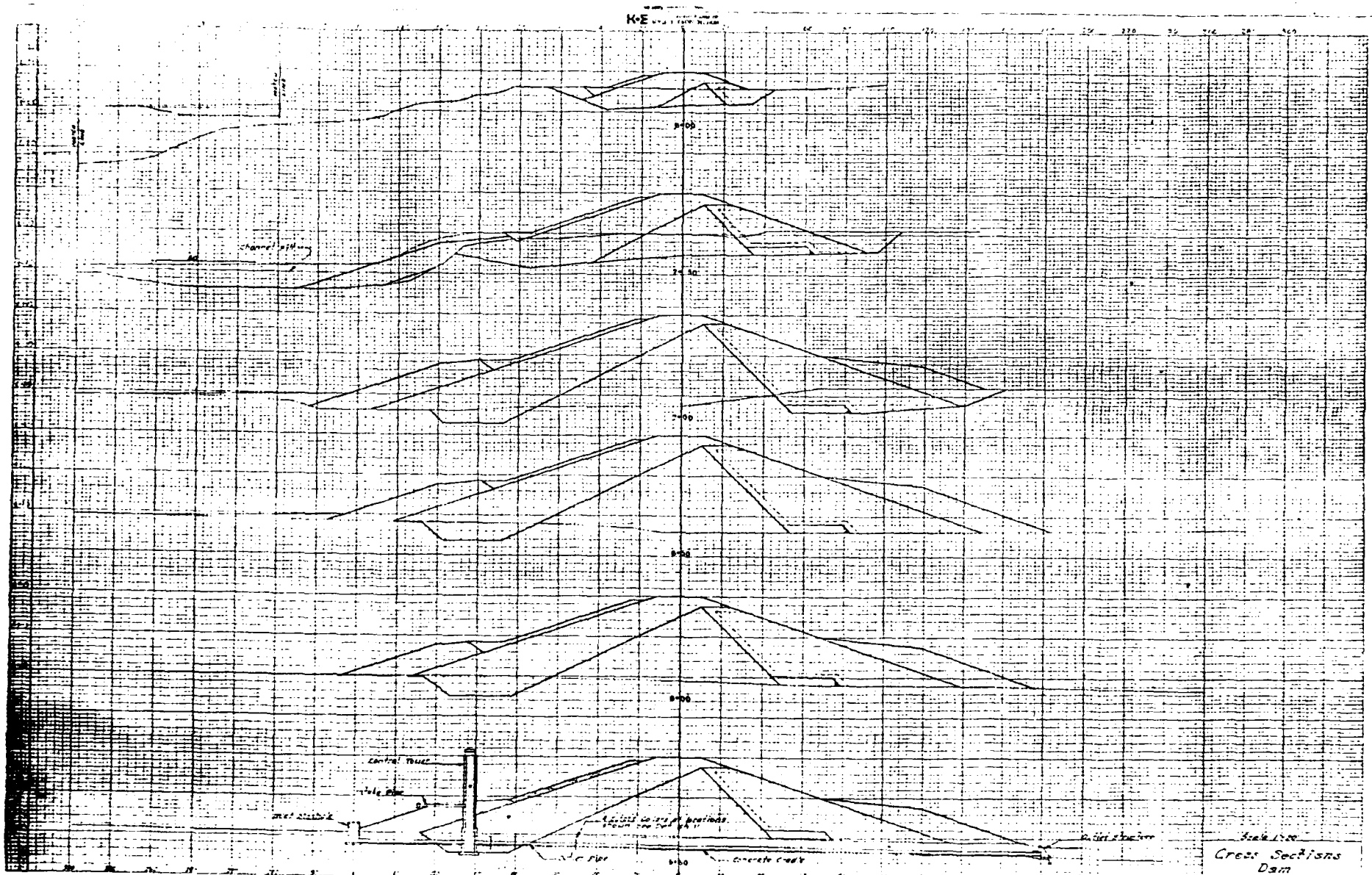


LARKIN & ASSOCIATES CONSULTING ENGINEERS KANSAS CITY, MO.

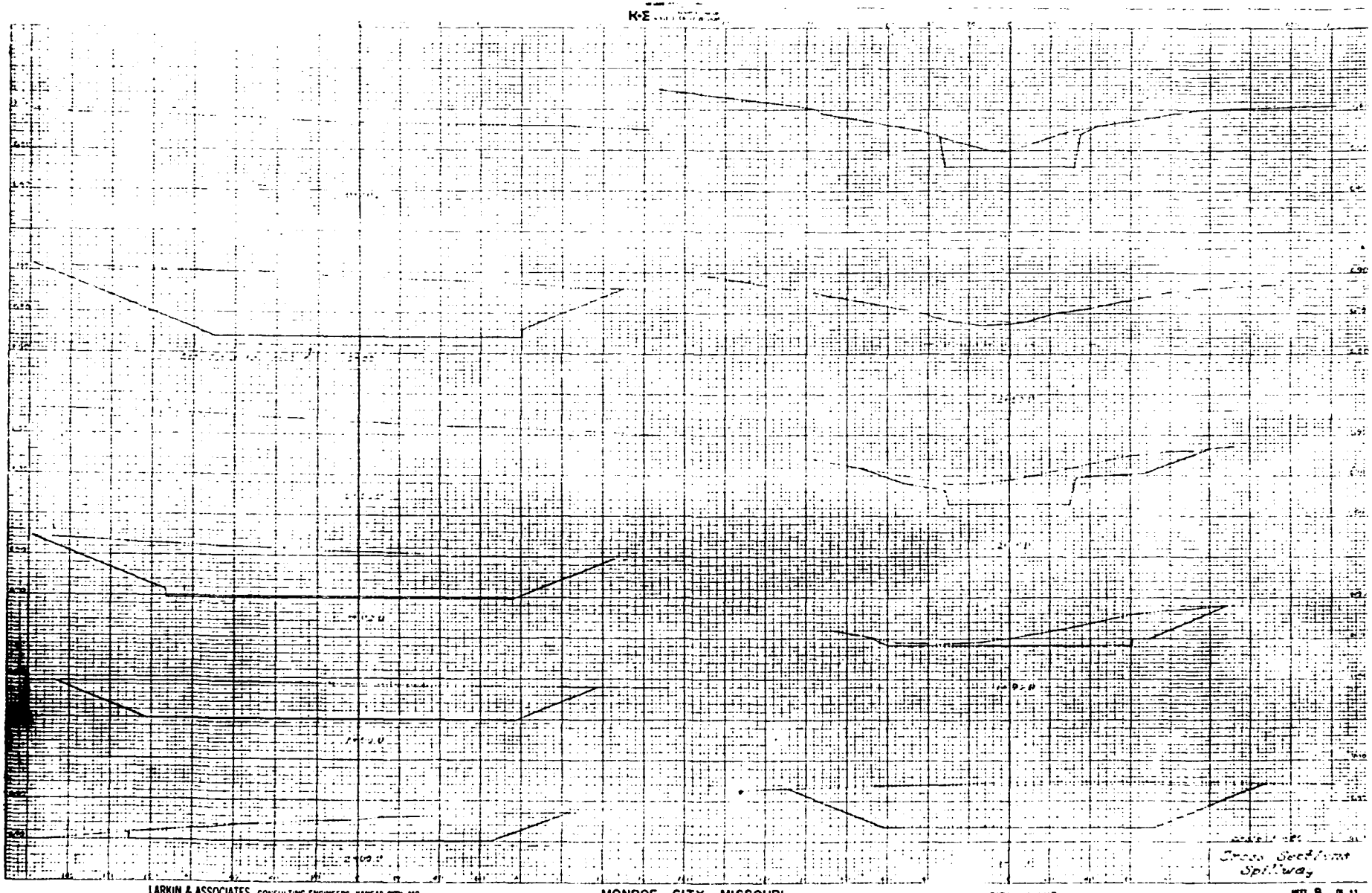
MONROE CITY, MISSOURI

MUNICIPAL LAKE

SHEET 6 11



LARKIN & ASSOCIATES CONSULTING ENGINEERS KANSAS CITY, MO MONROE CITY, MISSOURI MUNICIPAL LAKE SHEET 7 OF 11

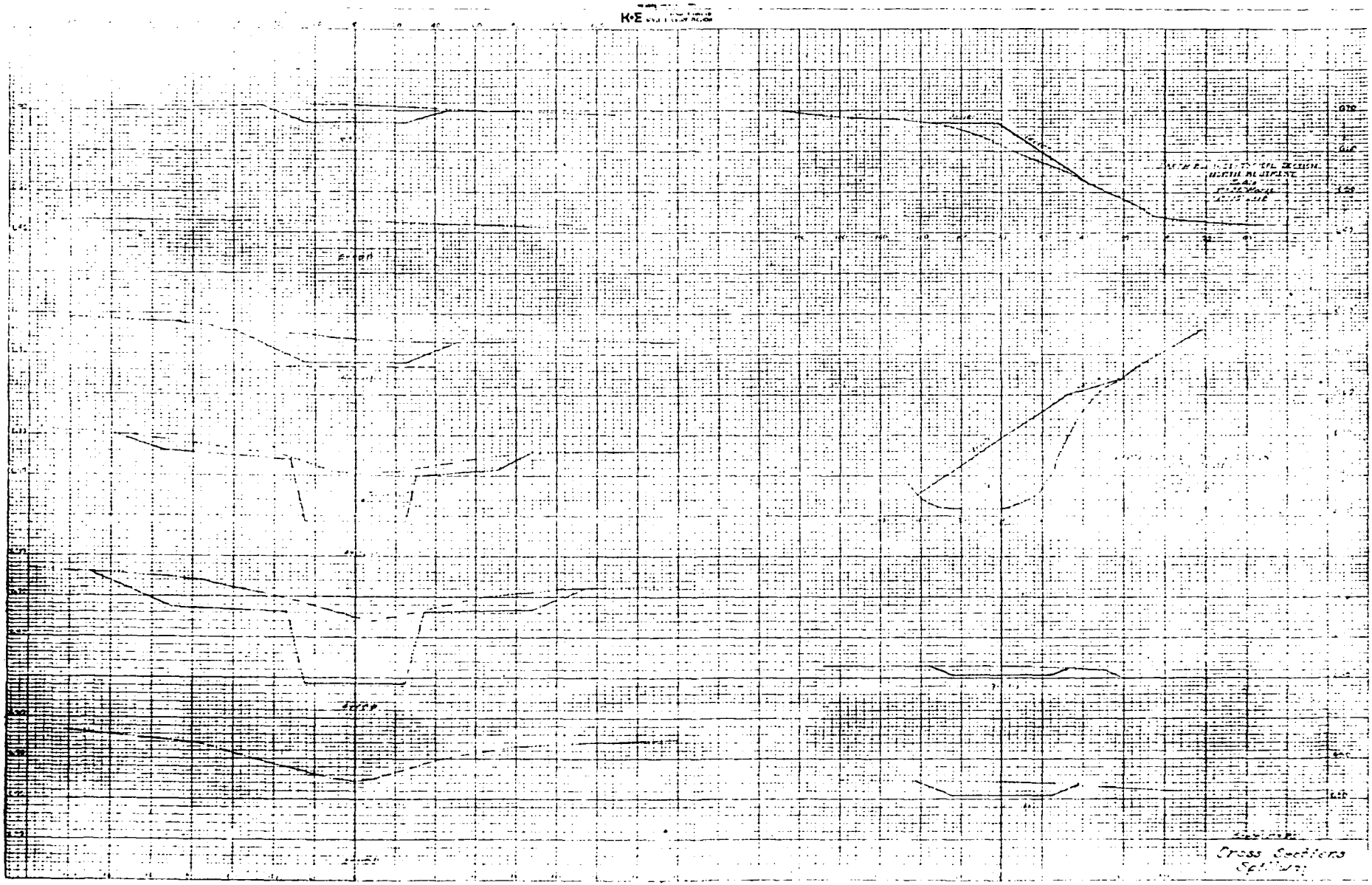


LARKIN & ASSOCIATES, CONSULTING ENGINEERS KANSAS CITY MO

MONROE CITY, MISSOURI

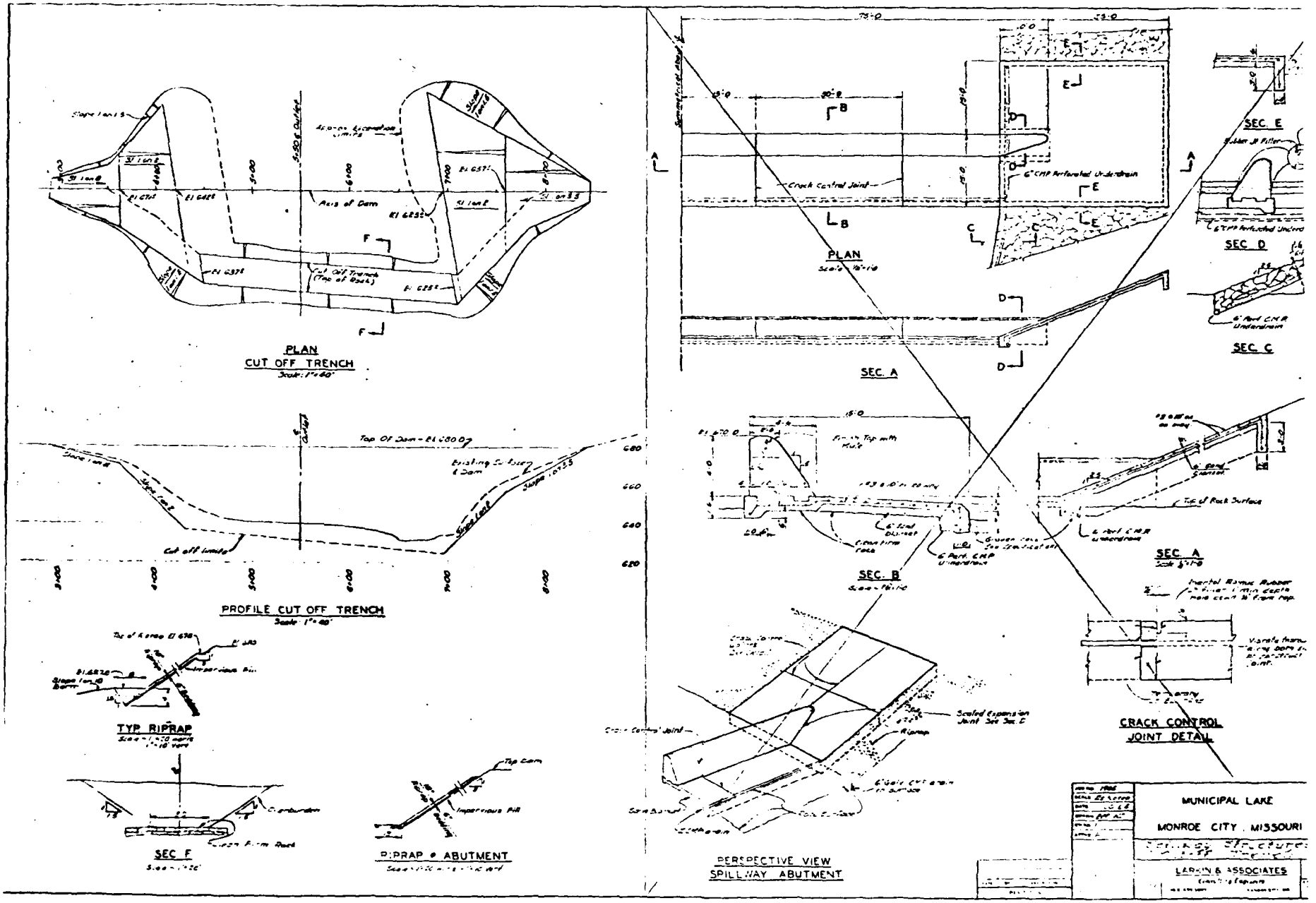
CIPAL LAKE

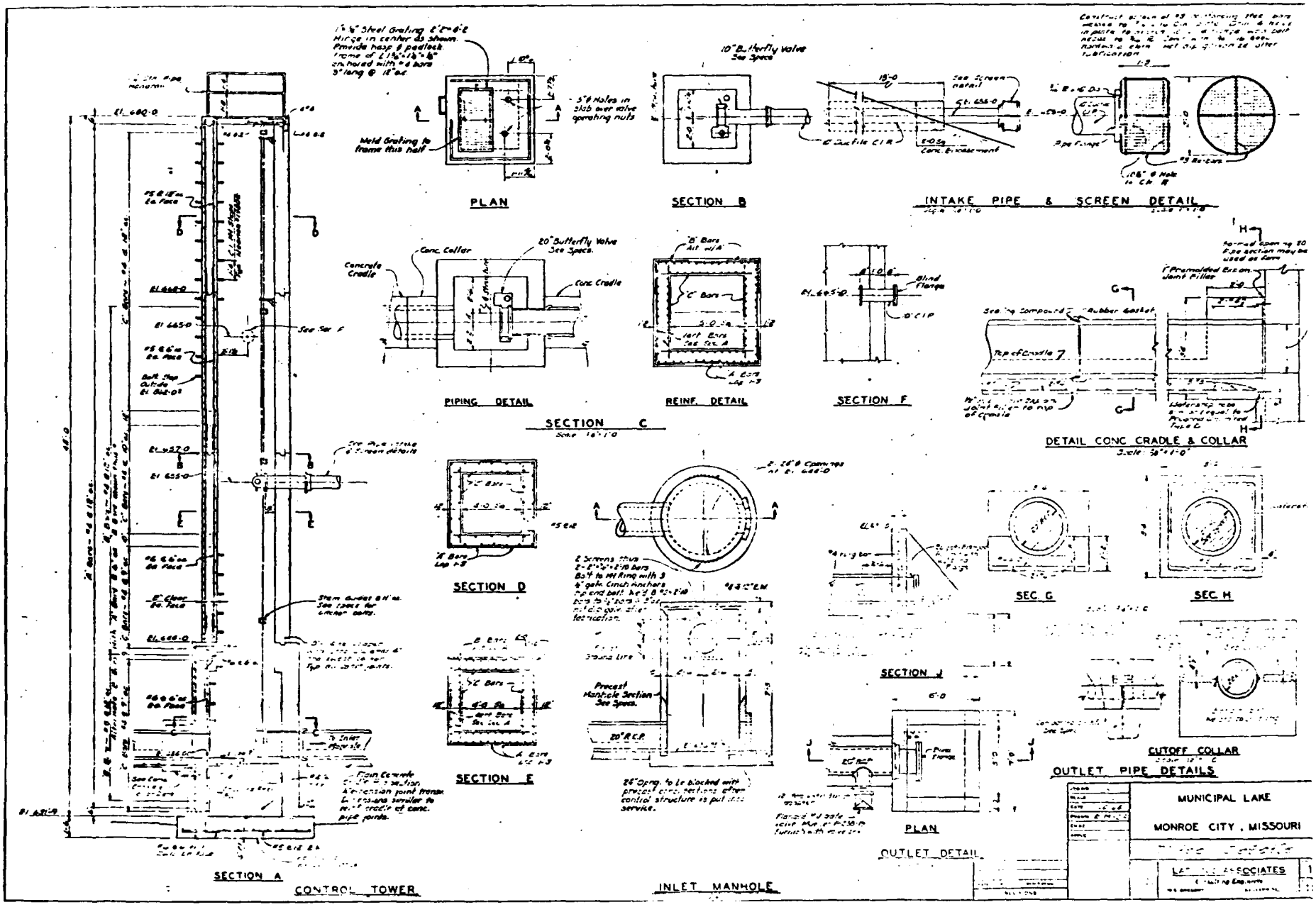
SHEET 8 OF 11

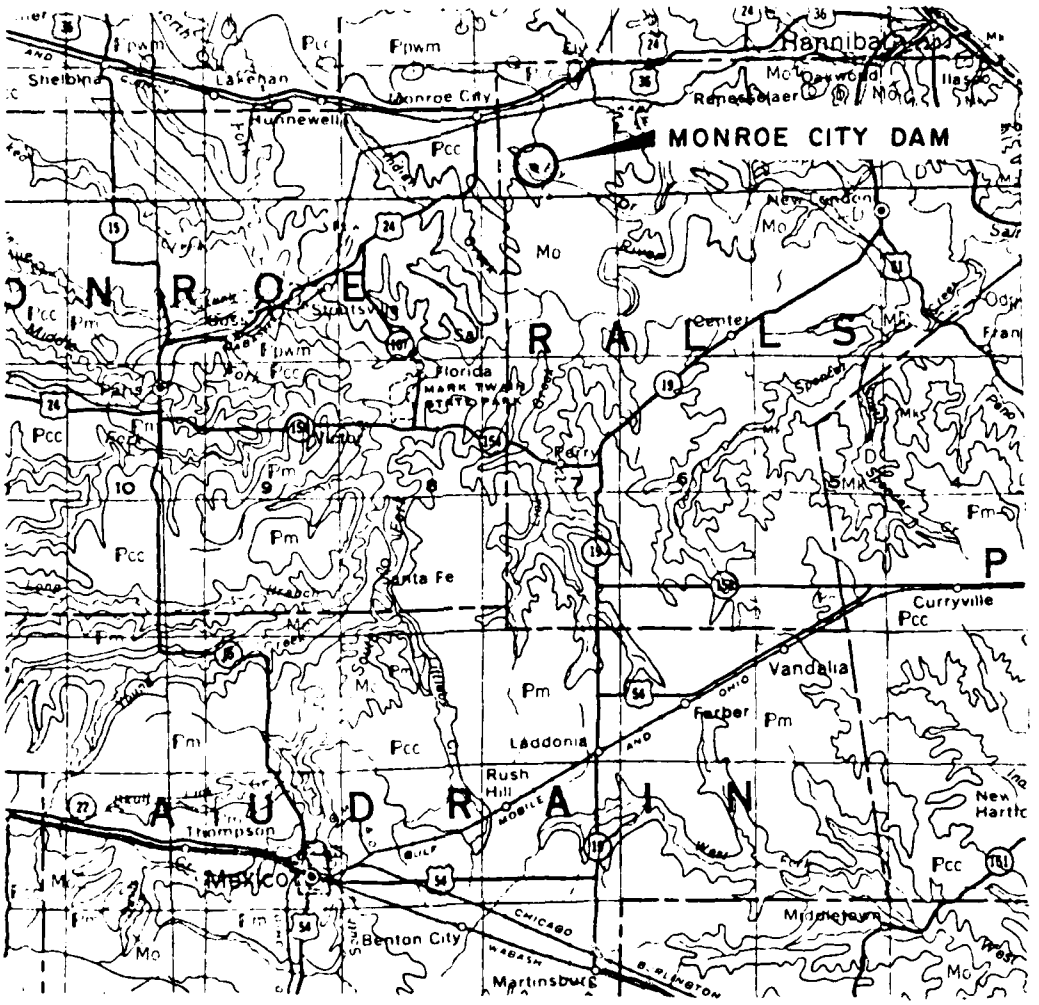


MONROE CITY, MISSOURI

MUNICIPAL LAKE


PLAN
CUT OFF TRENCH
PROFILE CUT OFF TRENCH
TYP RIPRAP
SEC F
RIPRAP @ ABUTMENT
PLAN
SEC A
SEC B
SEC C
SEC D
SEC E
PERSPECTIVE VIEW
SPILLWAY ABUTMENT
CRACK CONTROL
JOINT DETAIL
MUNICIPAL LAKE
MONROE CITY . MISSOURI
LARKIN & ASSOCIATES


PLAN
SECTION B
INTAKE PIPE & SCREEN DETAIL
PIPING DETAIL
REINF. DETAIL
SECTION F
SECTION C
DETAIL CONC CRADLE & COLLAR
SECTION D
SECTION E
SEC G
SEC H
SECTION J
CUTOFF COLLAR
OUTLET PIPE DETAILS
PLAN
OUTLET DETAIL
SECTION A
CONTROL TOWER
INLET MANHOLE
MUNICIPAL LAKE
MONROE CITY, MISSOURI



Explanation

Pennsylvanian System

P_{kc} - Kansas City group: cyclic deposits with numerous limestones.

P_{pwm} - Pleasanton group: sandstone channel member.

P_{m} - Marmaton group: cyclic deposits with limestones.

P_{cc} - Cherokee group: cyclic deposits, predominately shale, sandstone and coal beds.

Mississippian System

M_{m} - sandy, oolitic, fossiliferous, lithographic, or cherty limestones.

M_{o} - cherty, crinoidal limestone, with some shale.

M_{k} - intercalated limestones and shales.

Devonian System

D - limestones and sandstones.

Silurian System

S - limestones with some shale and chert.

Ordovician System

O_{mk} - shale and limestones.

O_{dp} - shale with thin fossiliferous limestone beds and dense limestone.

Reference: Geologic Map of Missouri, 1961, Division of Geological Survey and Water Resources, State of Missouri.

General Geologic Map

APPENDIX A

PHOTOGRAPHS TAKEN DURING INSPECTION

MONROE CITY DAM

Photo 1 - View along crest and upstream slope of dam taken at right abutment.

Photo 2 - Picture of upstream slope of embankment taken at right abutment.

Photo 3 - Picture of upstream slope of embankment taken at left abutment.

Photo 4 - Close-up of upstream slope of embankment near right side of dam.

Photo 5 - Picture of downstream slope of embankment taken downstream of dam. Note cattails in center of photograph at seepage area.

Photo 6 - Picture of seepage area to left of pump house. Again note cattails.

Photo 7 - Picture of intake structure for water supply piping.

Photo 8 - Picture of discharge headwall for outlet works.

Photo 9 - Picture of concrete spillway weir in left abutment of dam.

Photo 10 - Picture of approach channel for spillway taken at left bank of spillway.

Photo 11 - Picture of spillway discharge channel approximately 300 feet downstream of weir.

Photo 12 - Picture of typical rock cut in spillway discharge channel.

Photo 1 - View along crest and upstream slope of dam taken at right abutment.

Photo 2 - Picture of upstream slope of embankment taken at right abutment.

Photo 3 - Picture of upstream slope of embankment taken at left abutment.

Photo 4 - Close-up of upstream slope of embankment near right side of dam.

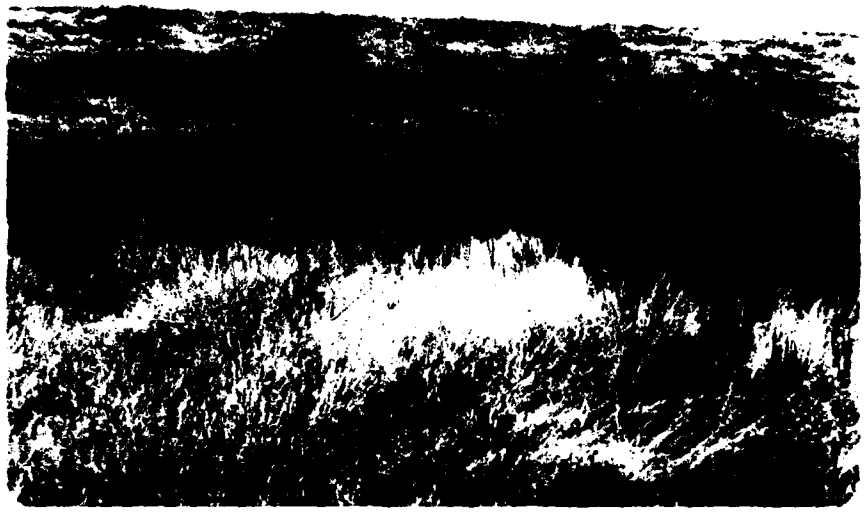


Photo 5 - Picture of downstream slope of embankment taken downstream of dam. Note cattails in center of photograph at seepage area.

Photo 6 - Picture of seepage area to left of pump house. Again note cattails.

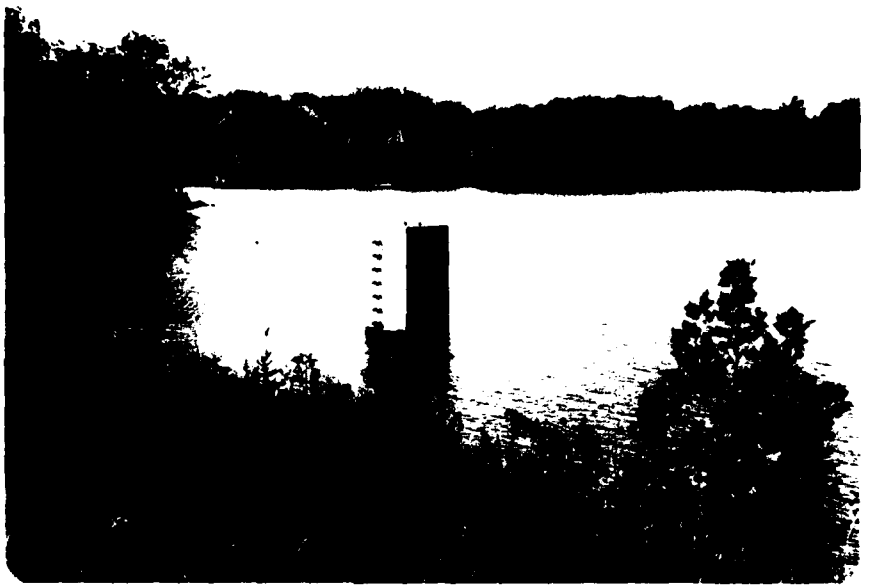


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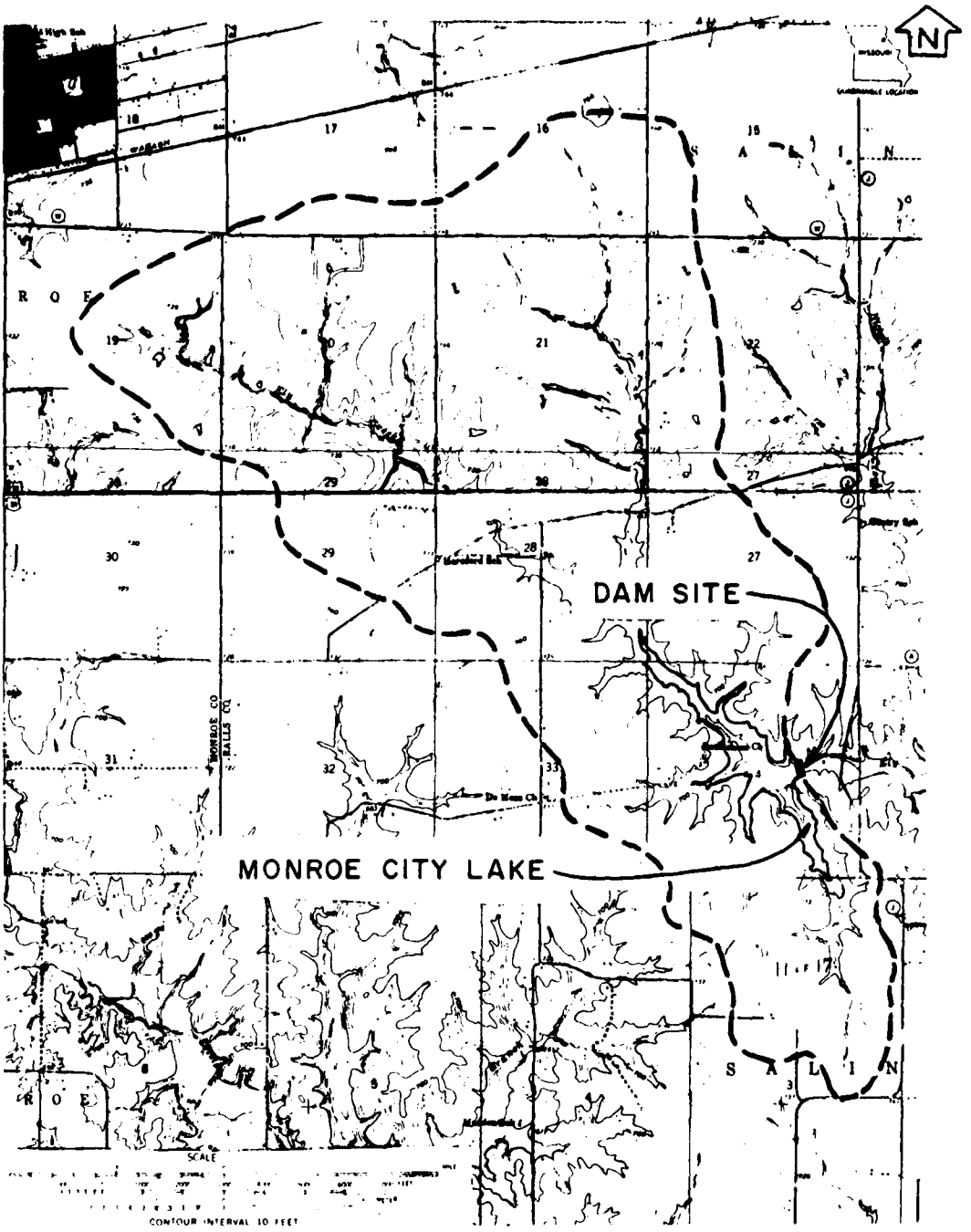
Photo 12 - Picture of typical rock cut in spillway discharge channel.

APPENDIX B

HYDROLOGIC COMPUTATIONS



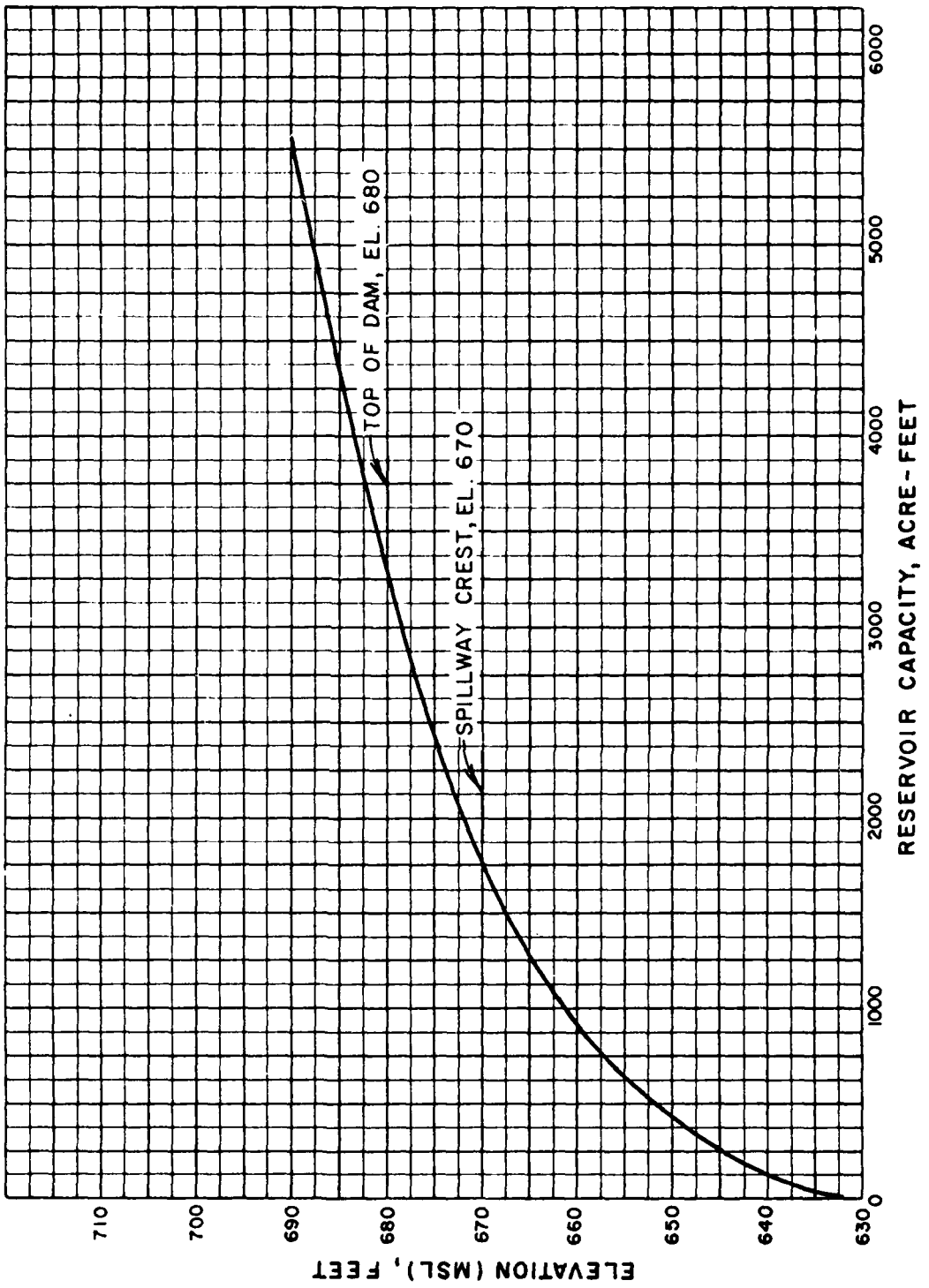
MONROE CITY DAM
DRAINAGE BASIN

MONROE CITY DAM

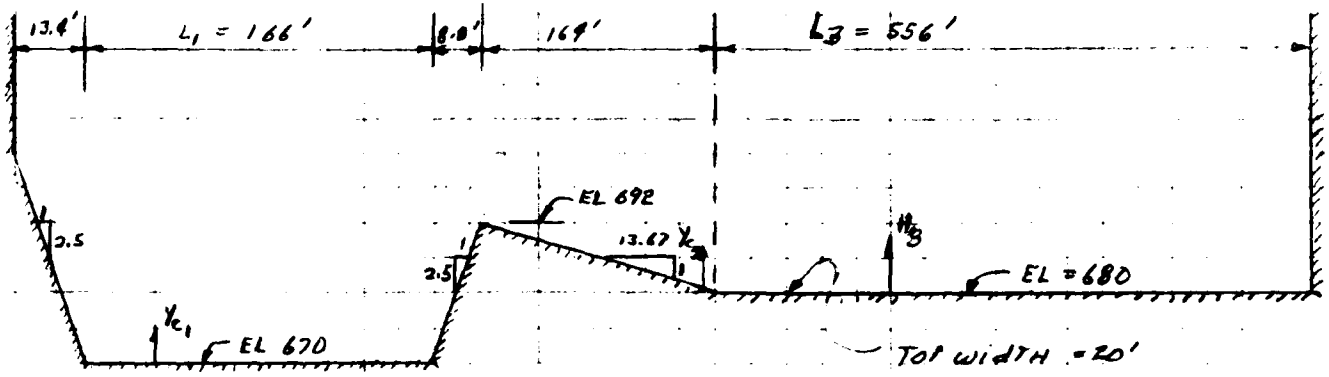
RESERVOIR AREA CAPACITY

Elevation MSL (feet)	Reservoir surface area (acres)	Increment-al Vol (ac-ft)	Accumulative Volume (ac-ft.)	Remarks
632	0	0	0	Stream bed elevation
670	131	1703	1703	Normal volume of 1703 AF is assumed to be at Spillway Crest El. 670
680	178	1545	3248	Top of dam
690	276	2270	5518	

Note: Normal volume of 1703 acre-feet (from Dam Inventory Table) is assumed to be at Spillway Crest and the rest of the volume figures are computed by multiplying the average area by the difference in elevations.



MONROE CITY DAM
RESERVOIR CAPACITY CURVE



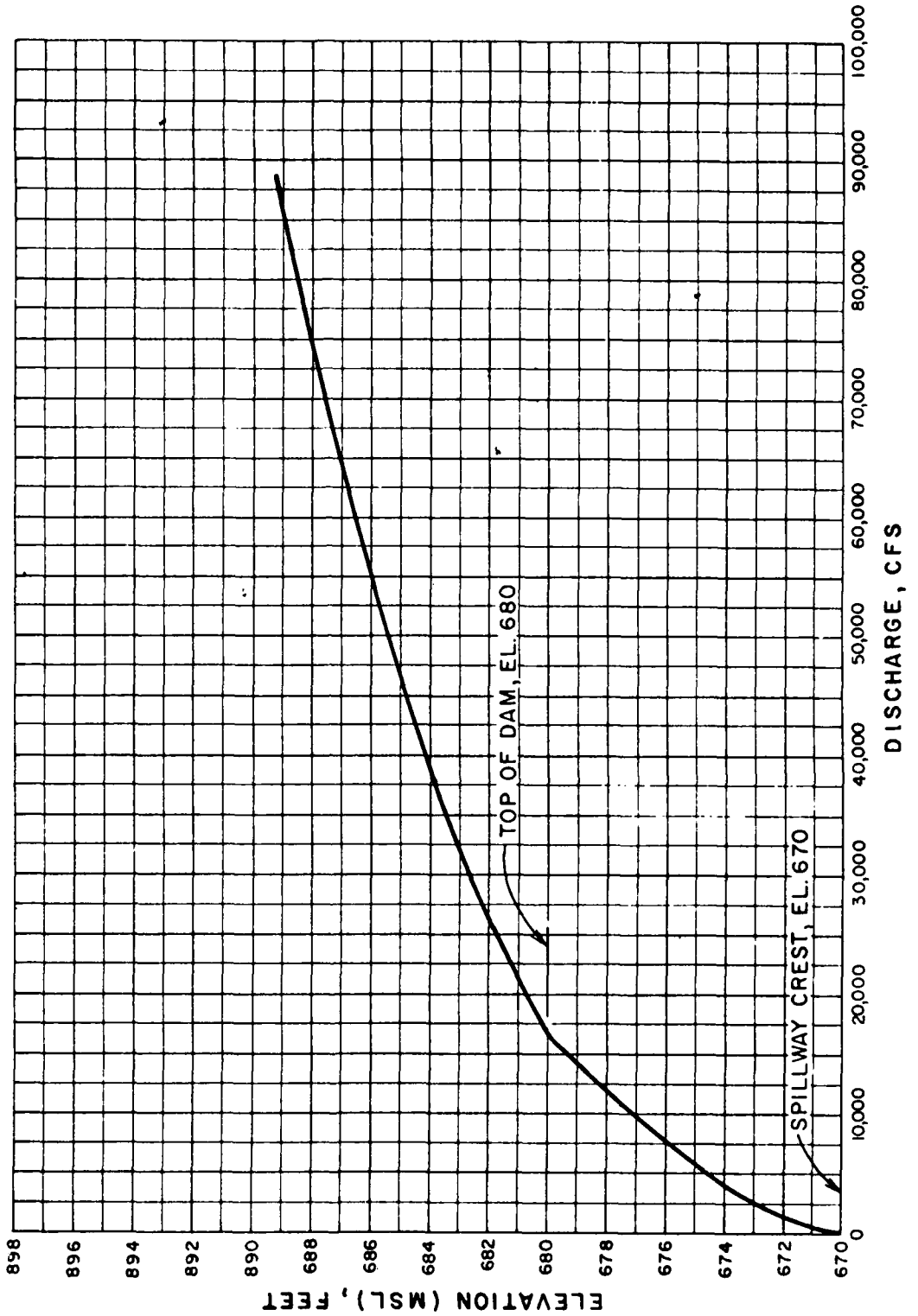
$b_1 = L_1 = 166'$, $z_1 = \frac{1}{2.5} = 0.40$, $b_2 = 0$, $z_2 = 13.67$,

USING CHOWS CRITICAL FLOW EQUATION FOR TRAPEZOIDS

$$Q_c = \frac{5.671[(b+zY)Y]^{1.5}}{(b+2zY)^{0.5}}, \quad A_c = (b+zY_c)Y_c$$

AND WEIR FLOW FOR L_3 PORTION, $Q = C_3 L_3 H_3^{1.5}$

Y_{c_1} (Ft)	A_{c_1} (Ft^2)	Q_{c_1} (CFS)	$V_{c_1} = \frac{Q_{c_1}}{A_{c_1}}$ (FPS)	$\frac{V_{c_1}^2}{2g}$ (Ft)	U.S. w.s. $= Y_{c_1} + \frac{V_{c_1}^2}{2g} + 670$ (Ft)	$Y_{c_2} \approx \frac{2}{3}$(U.S. w.s. -680)	A_{c_2} (Ft^2)	Q_{c_2} (CFS)	H_3 (Ft)	L_3 (Ft)	C_3	$Q_3 = C_3 L_3 H_3^{1.5}$ (CFS)	$Q_{TOTAL} = Q_{c_1} + Q_{c_2} + Q_3$ (CFS)
0	0	0	–	0	670.0	–	–	–	–	–	–	–	0
1.0	166.4	942.5	5.66	0.50	671.5	–	–	–	–	–	–	–	942
3.0	501.6	4909.4	9.79	1.49	674.5	–	–	–	–	–	–	–	4909
5.0	840.0	10589.0	12.61	2.47	677.5	–	–	–	–	–	–	–	10589
7.0	1191.6	17583.6	14.88	3.44	680.4	0.79	8.6	117.2	0.4	556	2.63	369.7	17958
9.0	1526.4	25697.3	16.84	4.40	683.4	2.27	35.2	2812.6	3.4	556	2.63	9167.5	37677
11.0	1874.4	34864.3	18.57	5.35	686.4	4.24	122.9	1014.8	6.4	556	2.63	23675.6	59679
13.0	2225.6	44831.3	20.1	6.27	689.3	6.18	261.0	2201.8	9.3	556	2.63	41472.6	88505
15.0	2580.0	55763.1	21.59	7.24	692.2	8.16	455.1	5213.2	12.2	556	2.63	62311.8	123228



MONROE CITY DAM
SPILLWAY & OVERTOP RATING CURVE

ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION - MISSOURI — SHEET NO. 1 OF 3
MONROE CITY DAM — JOB NO. 1223-001-1
UNIT HYDROGRAPH PARAMETERS — BY KLB — DATE 10-30-78

1. DRAINAGE AREA = 4666 A_c = 7.29 SQ. MI.

2. LENGTH OF STREAM, $L = \left(\frac{9.4 \times 3000}{5280}\right) = 3.56$ MI

3. DIFFERENCE IN ELEVATION, ΔH:

$\Delta H = 739 - 670 = 69$ FT.

4. TIME OF CONCENTRATION

$$T_c = \left(\frac{11.9 \times L^3}{\Delta H}\right)^{0.385}$$

$$= \left(\frac{11.9 \times 3.56^3}{69}\right)^{0.385}$$

$T_c = 2.20$ HR.

5. LAG TIME $L_t = 0.6 \times T_c$

$= 0.6 \times 2.20$

$L_t = 1.32$ HR

6. RAINFALL UNIT DURATION, D

$D \leq \frac{L_t}{4} = \frac{1.32}{4} = 0.331$ HR

USE $D = 0.25$ HR

7. TIME TO PEAK, $T_p = \frac{D}{2} + 0.6 \times T_c$

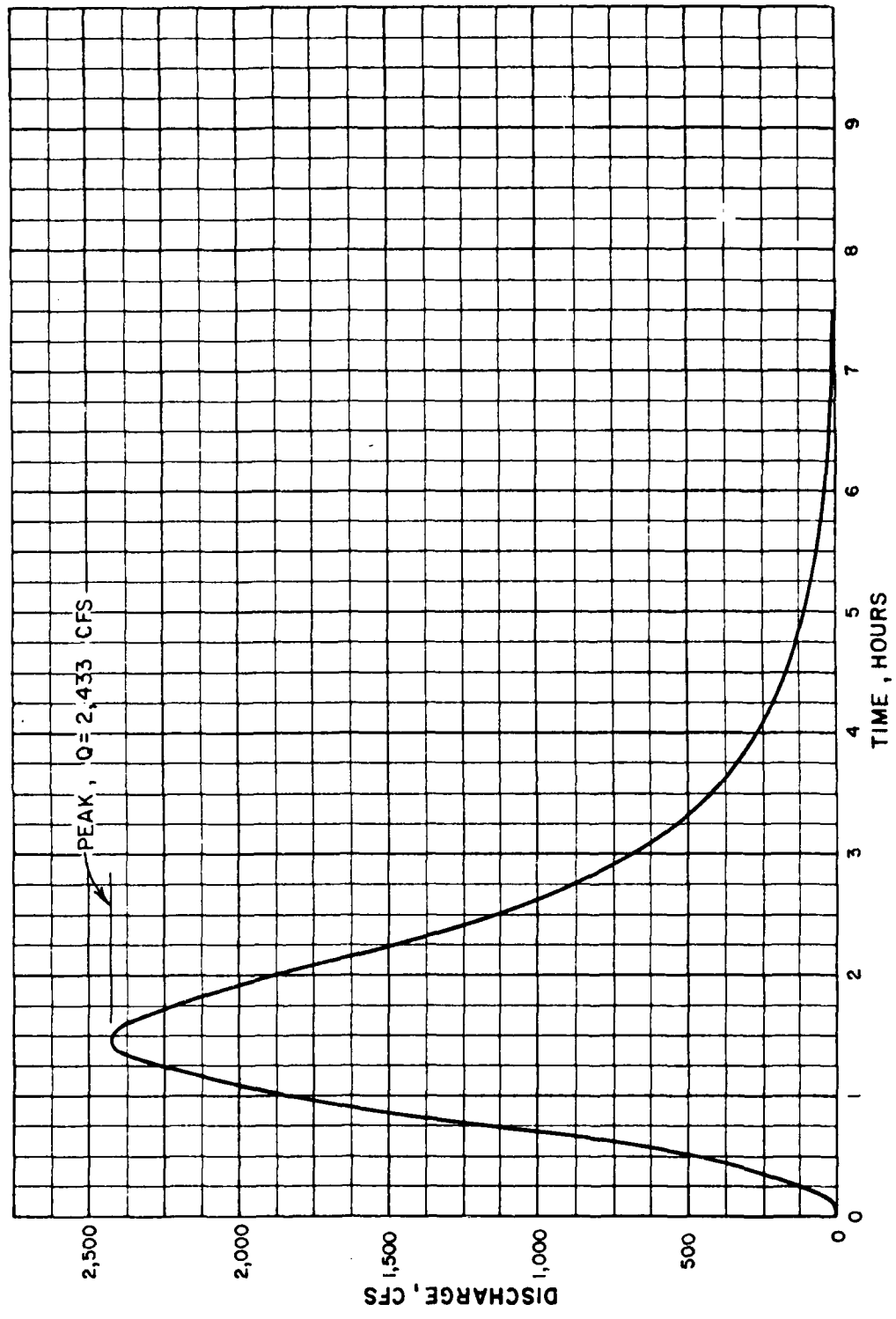
$= \frac{0.25}{2} + 1.32$

$T_p = \underline{1.45 \text{ HR}}$

8. $q_p = \frac{484 \times A}{T_p} = \frac{484 \times 7.29}{1.45} = \underline{2433 \text{ CFS}}$

9) CURVILINEAR UNIT HYDROGRAPH

TIME T/Tp	DISCHARGE RATIO Q/Qp	UNIT HYDROGRAPH	
		TIME, T (HOURS)	DISCHARGE (CFS)
0.0	0.000	0.00	0.00
0.1	0.015	0.15	36.50
0.2	0.075	0.29	182.48
0.3	0.16	0.44	389.28
0.4	0.28	0.58	681.24
0.5	0.45	0.73	1094.85
0.6	0.60	0.87	1459.80
0.7	0.77	1.02	1873.41
0.8	0.89	1.16	2165.37
0.9	0.97	1.31	2360.01
1.0	1.00	1.45	2433.00
1.1	0.98	1.60	2384.34
1.2	0.92	1.74	2238.36
1.3	0.84	1.89	2043.72
1.4	0.75	2.03	1824.75
1.5	0.66	2.18	1605.78
1.6	0.56	2.32	1362.48
1.8	0.42	2.61	1021.86
2.0	0.32	2.90	778.56
2.2	0.24	3.19	583.92
2.4	0.18	3.48	437.94
2.6	0.13	3.77	316.29
2.8	0.098	4.06	230.43
3.0	0.075	4.35	182.48
3.5	0.036	5.08	87.59
4.0	0.018	5.80	43.79
4.5	0.009	6.53	21.90
5.0	0.004	7.25	9.73



MONROE CITY DAM
15-MINUTE UNIT HYDROGRAPH

DETERMINATION OF PMS

1. Determine drainage area of the basin

   D.A. = 7.29 Sq.Mi.

2. Determine PMP Index rainfall :

   Location of centroid of basin:

   Long. 91.69°; Lat.: 39.63°

   → PMP for 200 Sq.mi & 24 hrs duration

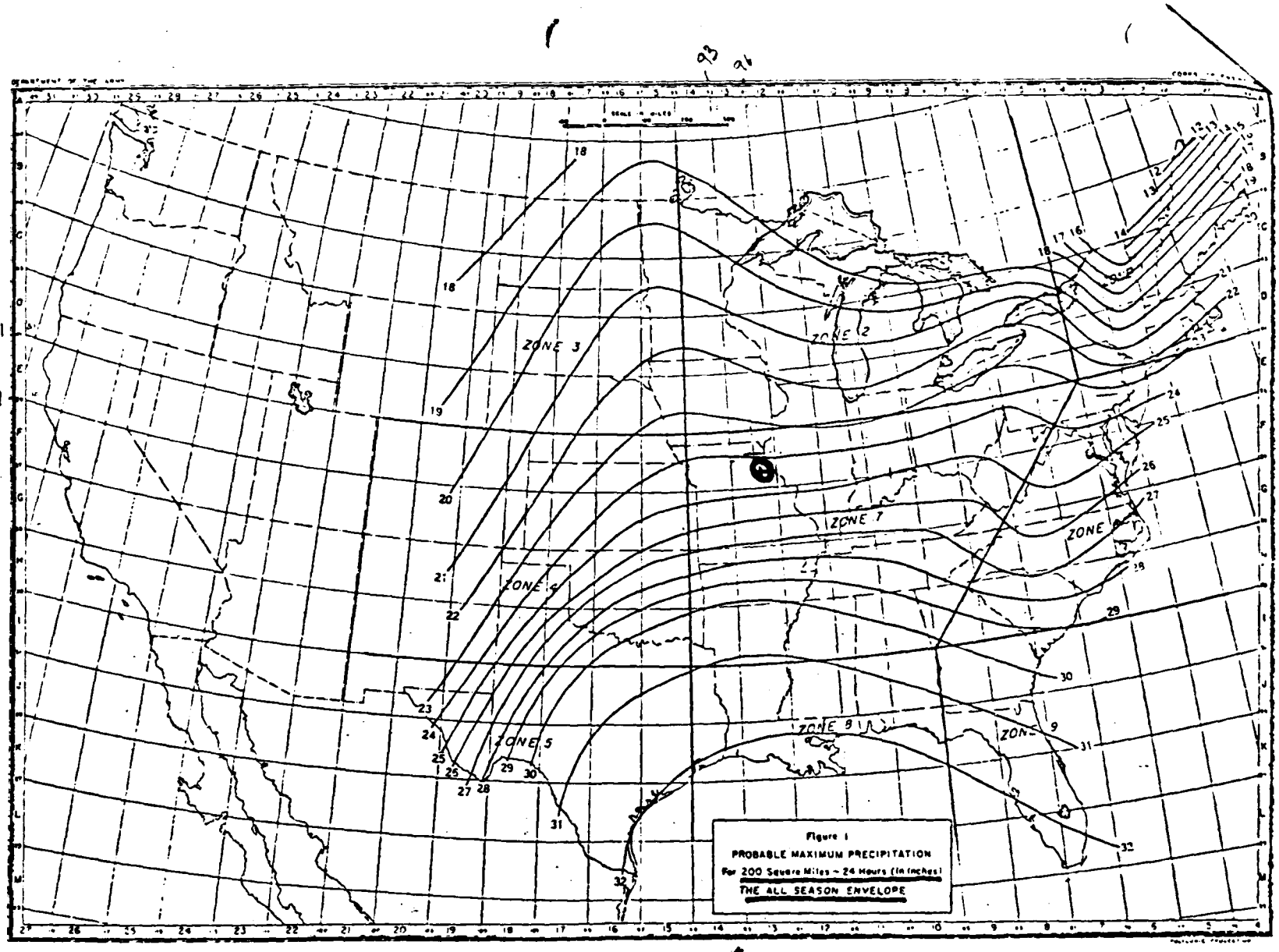
   = 24.4" (from Fig 1, HMR NO 33)

3. Determine basin rainfall interms of percentage of PMP Index rainfall for various durations:

   Location: Long. 91.69° ; Lat. 39.63°

   ⇒ Zone 7

Duration (Hrs.)	Percent of Index rainfall (%)	Total rainfall (Inches)	Rainfall increments (Inches)	Duration of increment (Hrs.)
6	100	24.4	24.4	6
12	120	29.3	4.9	6
24	130	31.7	2.4	12



24.4"

MONROE CITY DAM
DETERMINATION OF PMP

ECI-4 ENGINEERING CONSULTANTS, INC.

DAM SAFETY INSPECTION / MISSOURI — SHEET NO. 1 OF 1
MONROE CITY DAM — JOB NO. 1223-001
100-YEAR FLOOD BY REGRESSION EQUATION — BY MAS DATE 11/15/78

MONROE CITY DAM

100-YEAR FLOOD BY REGRESSION EQUATION

Regression equation for 100-year flood for Missouri:

$$Q_{100} = 851 A^{0.934 A^{-0.02}} S^{0.576}$$

where,

A = drainage area in Sq. mi.

S = main channel slope, ft./mi.
(Avg. slope between 0.1L & 0.85L,
L, being the length of the stream)

For Monroe City Dam:

$A = 7.29$ Sq. mi.

$$S = \frac{724 - 683}{0.75 \times 3.56} \text{ ft/mile} = 15.36 \text{ ft/mile}$$

$$Q_{100} = 851 (7.29)^{0.934 (7.29)^{-0.02}} (15.36)^{0.576}$$

$$= \underline{\underline{2442 \text{ cfs}}}$$

HEC1DB INPUT DATA

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  21 AUG 78
**********
```

```
     1          A1                    DAM SAFETY INSPECTION - MISSOURI
     2          A2                          MONROE CITY DAM
     3          A3              PMF AND 50 PERCENT PMF DETERMINATION AND ROUTING
     4          R    300         0       35         0         0         0         0         0         0         0
     5          B1     5
     6          J      1         2         1
     7          J1   1.0       0.5
     8          K      0        11                                                  1
     9          K1       INPUT PMP INDEX PRECIPITATION AND RATIOS, INPUT SCS UNIT HYDROGRAPH
    10          M      1        -1      7.29                   7.29       1.0
    11          P              24.80       100       120       130
    12          Y                                                          1.00      0.08
    13          U     31
    14          U1   0.0       130       490      1170      1870      2280      2433      2210      1880      1460
    15          U1  1140       875       665       520       340       260       212       160       128        95
    16          U1    75        60        45        35        30        25        20        15        10         5
    17          U1   0.0
    18          K                0.        1
    19          K      1        11                             2                  1
    20          K1       ROUTE HYDROGRAPH THROUGH MONROE CITY DAM
    21          Y                                  1         1
    22          Y1     1                                                      -670.        -1
    23          Y4 670.0     671.5     674.5     677.5     680.0     680.4     683.4     686.4     689.3     692.2
    24          Y5     0       942      4909     10589     17000     17958     35077     59499     88501    123228
    25          S5     0.     1763      3248      5518
    26          SE   632       670       680       690
    27          S5   670
    28          SD   680
    29          K    99
```

INFLOW PMF AND ONE-HALF PMF HYDROGRAPHS

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	11
ROUTE HYDROGRAPH TO	11
END OF NETWORK	

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  21 AUG 78
**********

RUN  DATE= 79/01/29.
     TIME= 07.27.49.
```

DAM SAFETY INSPECTION - MISSOURI
MONROE CITY DAM
PMF AND 50 PERCENT PMF DETERMINATION AND ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIOS= 1.00 .50

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INPUT PMP INDEX PRECIPITATION AND RATIOS, INPUT SCS UNI

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
11	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	-1	7.29	0.00	7.29	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.40	100.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.08	0.00	0.00

GIVEN UNIT GRAPH, NUMGO= 31

0.	130.	490.	1170.	1870.	2280.	2433.	2210.	1880.	1460.
1140.	875.	665.	520.	340.	260.	212.	160.	128.	95.
75.	60.	45.	35.	30.	25.	20.	15.	10.	5.
0.									

UNIT GRAPH TOTALS 18638. CFS OR .99 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

1.01	.15	1	.04	0.00	.04	0.	1.02	13.45	151	0.00	0.00	0.00	0.
1.01	.30	2	.04	0.00	.04	0.	1.02	14.00	152	0.00	0.00	0.00	0.
1.01	.45	3	.04	0.00	.04	0.	1.02	14.15	153	0.00	0.00	0.00	0.
1.01	1.00	4	.04	0.00	.04	0.	1.02	14.30	154	0.00	0.00	0.00	0.
1.01	1.15	5	.04	0.00	.04	0.	1.02	14.45	155	0.00	0.00	0.00	0.
1.01	1.30	6	.04	0.00	.04	0.	1.02	15.00	156	0.00	0.00	0.00	0.
1.01	1.45	7	.04	0.00	.04	0.	1.02	15.15	157	0.00	0.00	0.00	0.
1.01	2.00	8	.04	0.00	.04	0.	1.02	15.30	158	0.00	0.00	0.00	0.
1.01	2.15	9	.04	0.00	.04	0.	1.02	15.45	159	0.00	0.00	0.00	0.
1.01	2.30	10	.04	0.00	.04	0.	1.02	16.00	160	0.00	0.00	0.00	0.
1.01	2.45	11	.04	0.00	.04	0.	1.02	16.15	161	0.00	0.00	0.00	0.
1.01	3.00	12	.04	0.00	.04	0.	1.02	16.30	162	0.00	0.00	0.00	0.
1.01	3.15	13	.04	0.00	.04	0.	1.02	16.45	163	0.00	0.00	0.00	0.
1.01	3.30	14	.04	0.00	.04	0.	1.02	17.00	164	0.00	0.00	0.00	0.
1.01	3.45	15	.04	0.00	.04	0.	1.02	17.15	165	0.00	0.00	0.00	0.
1.01	4.00	16	.04	0.00	.04	0.	1.02	17.30	166	0.00	0.00	0.00	0.
1.01	4.15	17	.04	0.00	.04	0.	1.02	17.45	167	0.00	0.00	0.00	0.
1.01	4.30	18	.04	0.00	.04	0.	1.02	18.00	168	0.00	0.00	0.00	0.
1.01	4.45	19	.04	0.00	.04	0.	1.02	18.15	169	0.00	0.00	0.00	0.
1.01	5.00	20	.04	0.00	.04	0.	1.02	18.30	170	0.00	0.00	0.00	0.
1.01	5.15	21	.04	0.00	.04	0.	1.02	18.45	171	0.00	0.00	0.00	0.
1.01	5.30	22	.04	0.00	.04	0.	1.02	19.00	172	0.00	0.00	0.00	0.
1.01	5.45	23	.04	0.00	.04	0.	1.02	19.15	173	0.00	0.00	0.00	0.
1.01	6.00	24	.04	0.00	.04	0.	1.02	19.30	174	0.00	0.00	0.00	0.
1.01	6.15	25	.20	.16	.04	0.	1.02	19.45	175	0.00	0.00	0.00	0.
1.01	6.30	26	.20	.18	.02	21.	1.02	20.00	176	0.00	0.00	0.00	0.
1.01	6.45	27	.20	.18	.02	103.	1.02	20.15	177	0.00	0.00	0.00	0.
1.01	7.00	28	.20	.18	.02	303.	1.02	20.30	178	0.00	0.00	0.00	0.
1.01	7.15	29	.20	.18	.02	631.	1.02	20.45	179	0.00	0.00	0.00	0.
1.01	7.30	30	.20	.18	.02	1040.	1.02	21.00	180	0.00	0.00	0.00	0.
1.01	7.45	31	.20	.18	.02	1482.	1.02	21.15	181	0.00	0.00	0.00	0.
1.01	8.00	32	.20	.18	.02	1892.	1.02	21.30	182	0.00	0.00	0.00	0.
1.01	8.15	33	.20	.18	.02	2244.	1.02	21.45	183	0.00	0.00	0.00	0.
1.01	8.30	34	.20	.18	.02	2521.	1.02	22.00	184	0.00	0.00	0.00	0.
1.01	8.45	35	.20	.18	.02	2737.	1.02	22.15	185	0.00	0.00	0.00	0.
1.01	9.00	36	.20	.18	.02	2903.	1.02	22.30	186	0.00	0.00	0.00	0.
1.01	9.15	37	.20	.18	.02	3029.	1.02	22.45	187	0.00	0.00	0.00	0.
1.01	9.30	38	.20	.18	.02	3128.	1.02	23.00	188	0.00	0.00	0.00	0.
1.01	9.45	39	.20	.18	.02	3194.	1.02	23.15	189	0.00	0.00	0.00	0.
1.01	10.00	40	.20	.18	.02	3244.	1.02	23.30	190	0.00	0.00	0.00	0.
1.01	10.15	41	.20	.18	.02	3283.	1.02	23.45	191	0.00	0.00	0.00	0.
1.01	10.30	42	.20	.18	.02	3314.	1.03	0.00	192	0.00	0.00	0.00	0.
1.01	10.45	43	.20	.18	.02	3338.	1.03	.15	193	0.00	0.00	0.00	0.
1.01	11.00	44	.20	.18	.02	3356.	1.03	.30	194	0.00	0.00	0.00	0.
1.01	11.15	45	.20	.18	.02	3370.	1.03	.45	195	0.00	0.00	0.00	0.
1.01	11.30	46	.20	.18	.02	3382.	1.03	1.00	196	0.00	0.00	0.00	0.
1.01	11.45	47	.20	.18	.02	3390.	1.03	1.15	197	0.00	0.00	0.00	0.
1.01	12.00	48	.20	.18	.02	3397.	1.03	1.30	198	0.00	0.00	0.00	0.
1.01	12.15	49	.61	.59	.02	3403.	1.03	1.45	199	0.00	0.00	0.00	0.
1.01	12.30	50	.61	.59	.02	3460.	1.03	2.00	200	0.00	0.00	0.00	0.
1.01	12.45	51	.61	.59	.02	3663.	1.03	2.15	201	0.00	0.00	0.00	0.
1.01	13.00	52	.61	.59	.02	4142.	1.03	2.30	202	0.00	0.00	0.00	0.
1.01	13.15	53	.73	.71	.02	4904.	1.03	2.45	203	0.00	0.00	0.00	0.
1.01	13.30	54	.73	.71	.02	5848.	1.03	3.00	204	0.00	0.00	0.00	0.
1.01	13.45	55	.73	.71	.02	6898.	1.03	3.15	205	0.00	0.00	0.00	0.
1.01	14.00	56	.73	.71	.02	7939.	1.03	3.30	206	0.00	0.00	0.00	0.
1.01	14.15	57	.92	.90	.02	8932.	1.03	3.45	207	0.00	0.00	0.00	0.
1.01	14.30	58	.92	.90	.02	9827.	1.03	4.00	208	0.00	0.00	0.00	0.
1.01	14.45	59	.92	.90	.02	10678.	1.03	4.15	209	0.00	0.00	0.00	0.

1.01	15.00	60	.92	.90	.02	13917.	1.03	4.30	210	0.00	0.00	0.00	0.		
1.01	15.15	61	.93	.91	.02	13359.	1.03	4.45	211	0.00	0.00	0.00	0.		
1.01	15.30	62	1.85	1.83	.02	13168.	1.03	5.00	212	0.00	0.00	0.00	0.		
1.01	15.45	63	5.19	5.17	.02	14017.	1.03	5.15	213	0.00	0.00	0.00	0.		
1.01	16.00	64	1.30	1.28	.02	15536.	1.03	5.30	214	0.00	0.00	0.00	0.		
1.01	16.15	65	.85	.83	.02	16284.	1.03	5.45	215	0.00	0.00	0.00	0.		
1.01	16.30	66	.85	.83	.02	22361.	1.03	6.00	216	0.00	0.00	0.00	0.		
1.01	16.45	67	.85	.83	.02	26295.	1.03	6.15	217	0.00	0.00	0.00	0.		
1.01	17.00	68	.85	.83	.02	28617.	1.03	6.30	218	0.00	0.00	0.00	0.		
1.01	17.15	69	.67	.65	.02	29279.	1.03	6.45	219	0.00	0.00	0.00	0.		
1.01	17.30	70	.67	.65	.02	28085.	1.03	7.00	220	0.00	0.00	0.00	0.		
1.01	17.45	71	.67	.65	.02	26008.	1.03	7.15	221	0.00	0.00	0.00	0.		
1.01	18.00	72	.67	.65	.02	23505.	1.03	7.30	222	0.00	0.00	0.00	0.		
1.01	18.15	73	.06	.04	.02	21327.	1.03	7.45	223	0.00	0.00	0.00	0.		
1.01	18.30	74	.06	.04	.02	19334.	1.03	8.00	224	0.00	0.00	0.00	0.		
1.01	18.45	75	.06	.04	.02	17419.	1.03	8.15	225	0.00	0.00	0.00	0.		
1.01	19.00	76	.06	.04	.02	15404.	1.03	8.30	226	0.00	0.00	0.00	0.		
1.01	19.15	77	.06	.04	.02	12999.	1.03	8.45	227	0.00	0.00	0.00	0.		
1.01	19.30	78	.06	.04	.02	10869.	1.03	9.00	228	0.00	0.00	0.00	0.		
1.01	19.45	79	.06	.04	.02	8881.	1.03	9.15	229	0.00	0.00	0.00	0.		
1.01	20.00	80	.06	.04	.02	7094.	1.03	9.30	230	0.00	0.00	0.00	0.		
1.01	20.15	81	.06	.04	.02	5631.	1.03	9.45	231	0.00	0.00	0.00	0.		
1.01	20.30	82	.06	.04	.02	4468.	1.03	10.00	232	0.00	0.00	0.00	0.		
1.01	20.45	83	.06	.04	.02	3594.	1.03	10.15	233	0.00	0.00	0.00	0.		
1.01	21.00	84	.06	.04	.02	2923.	1.03	10.30	234	0.00	0.00	0.00	0.		
1.01	21.15	85	.06	.04	.02	2397.	1.03	10.45	235	0.00	0.00	0.00	0.		
1.01	21.30	86	.06	.04	.02	1994.	1.03	11.00	236	0.00	0.00	0.00	0.		
1.01	21.45	87	.06	.04	.02	1731.	1.03	11.15	237	0.00	0.00	0.00	0.		
1.01	22.00	88	.06	.04	.02	1525.	1.03	11.30	238	0.00	0.00	0.00	0.		
1.01	22.15	89	.06	.04	.02	1352.	1.03	11.45	239	0.00	0.00	0.00	0.		
1.01	22.30	90	.06	.04	.02	1214.	1.03	12.00	240	0.00	0.00	0.00	0.		
1.01	22.45	91	.06	.04	.02	1098.	1.03	12.15	241	0.00	0.00	0.00	0.		
1.01	23.00	92	.06	.04	.02	1005.	1.03	12.30	242	0.00	0.00	0.00	0.		
1.01	23.15	93	.06	.04	.02	930.	1.03	12.45	243	0.00	0.00	0.00	0.		
1.01	23.30	94	.06	.04	.02	886.	1.03	13.00	244	0.00	0.00	0.00	0.		
1.01	23.45	95	.06	.04	.02	855.	1.03	13.15	245	0.00	0.00	0.00	0.		
1.02	0.00	96	.06	.04	.02	831.	1.03	13.30	246	0.00	0.00	0.00	0.		
1.02	.15	97	0.00	0.00	0.00	811.	1.03	13.45	247	0.00	0.00	0.00	0.		
1.02	.30	98	0.00	0.00	0.00	789.	1.03	14.00	248	0.00	0.00	0.00	0.		
1.02	.45	99	0.00	0.00	0.00	757.	1.03	14.15	249	0.00	0.00	0.00	0.		
1.02	1.00	100	0.00	0.00	0.00	700.	1.03	14.30	250	0.00	0.00	0.00	0.		
1.02	1.15	101	0.00	0.00	0.00	617.	1.03	14.45	251	0.00	0.00	0.00	0.		
1.02	1.30	102	0.00	0.00	0.00	521.	1.03	15.00	252	0.00	0.00	0.00	0.		
1.02	1.45	103	0.00	0.00	0.00	421.	1.03	15.15	253	0.00	0.00	0.00	0.		
1.02	2.00	104	0.00	0.00	0.00	330.	1.03	15.30	254	0.00	0.00	0.00	0.		
1.02	2.15	105	0.00	.00	0.00	253.	1.03	15.45	255	0.00	0.00	0.00	0.		
1.02	2.30	106	0.00	0.00	0.00	193.	1.03	16.00	256	0.00	0.00	0.00	0.		
1.02	2.45	107	0.00	0.00	0.00	147.	1.03	16.15	257	0.00	0.00	0.00	0.		
1.02	3.00	108	0.00	0.00	0.00	111.	1.03	16.30	258	0.00	0.00	0.00	0.		
1.02	3.15	109	0.00	0.00	0.00	83.	1.03	16.45	259	0.00	0.00	0.00	0.		
1.02	3.30	110	0.00	0.00	0.00	62.	1.03	17.00	260	0.00	0.00	0.00	0.		
1.02	3.45	111	0.00	0.00	0.00	48.	1.03	17.15	261	0.00	0.00	0.00	0.		
1.02	4.00	112	0.00	0.00	0.00	38.	1.03	17.30	262	0.00	0.00	0.00	0.		
1.02	4.15	113	0.00	0.00	0.00	29.	1.03	17.45	263	0.00	0.00	0.00	0.		
1.02	4.30	114	0.00	0.00	0.00	22.	1.03	18.00	264	0.00	0.00	0.00	0.		
1.02	4.45	115	0.00	0.00	0.00	17.	1.03	18.15	265	0.00	0.00	0.00	0.		
1.02	5.00	116	0.00	0.00	0.00	13.	1.03	18.30	266	0.00	0.00	0.00	0.		
1.02	5.15	117	0.00	0.00	0.00	10.	1.03	18.45	267	0.00	0.00	0.00	0.		
1.02	5.30	118	0.00	0.00	0.00	8.	1.03	19.00	268	0.00	0.00	0.00	0.		
1.02	5.45	119	0.00	0.00	0.00	6.	1.03	19.15	269	0.00	0.00	0.00	0.		

1.02	6.00	120	0.00	0.00	0.00	4.	1.03	19.30	270	0.00	0.00	0.00	0.
1.02	6.15	121	0.00	0.00	0.00	3.	1.03	19.45	271	0.00	0.00	0.00	0.
1.02	6.30	122	0.00	0.00	0.00	2.	1.03	20.00	272	0.00	0.00	0.00	0.
1.02	6.45	123	0.00	0.00	0.00	1.	1.03	20.15	273	0.00	0.00	0.00	0.
1.02	7.00	124	0.00	0.00	0.00	1.	1.03	20.30	274	0.00	0.00	0.00	0.
1.02	7.15	125	0.00	0.00	0.00	0.	1.03	20.45	275	0.00	0.00	0.00	0.
1.02	7.30	126	0.00	0.00	0.00	0.	1.03	21.00	276	0.00	0.00	0.00	0.
1.02	7.45	127	0.00	0.00	0.00	0.	1.03	21.15	277	0.00	0.00	0.00	0.
1.02	8.00	128	0.00	0.00	0.00	0.	1.03	21.30	278	0.00	0.00	0.00	0.
1.02	8.15	129	0.00	0.00	0.00	0.	1.03	21.45	279	0.00	0.00	0.00	0.
1.02	8.30	130	0.00	0.00	0.00	0.	1.03	22.00	280	0.00	0.00	0.00	0.
1.02	8.45	131	0.00	0.00	0.00	0.	1.03	22.15	281	0.00	0.00	0.00	0.
1.02	9.00	132	0.00	0.00	0.00	0.	1.03	22.30	282	0.00	0.00	0.00	0.
1.02	9.15	133	0.00	0.00	0.00	0.	1.03	22.45	283	0.00	0.00	0.00	0.
1.02	9.30	134	0.00	0.00	0.00	0.	1.03	23.00	284	0.00	0.00	0.00	0.
1.02	9.45	135	0.00	0.00	0.00	0.	1.03	23.15	285	0.00	0.00	0.00	0.
1.02	10.00	136	0.00	0.00	0.00	0.	1.03	23.30	286	0.00	0.00	0.00	0.
1.02	10.15	137	0.00	0.00	0.00	0.	1.03	23.45	287	0.00	0.00	0.00	0.
1.02	10.30	138	0.00	0.00	0.00	0.	1.04	0.00	288	0.00	0.00	0.00	0.
1.02	10.45	139	0.00	0.00	0.00	0.	1.04	.15	289	0.00	0.00	0.00	0.
1.02	11.00	140	0.00	0.00	0.00	0.	1.04	.30	290	0.00	0.00	0.00	0.
1.02	11.15	141	0.00	0.00	0.00	0.	1.04	.45	291	0.00	0.00	0.00	0.
1.02	11.30	142	0.00	0.00	0.00	0.	1.04	1.00	292	0.00	0.00	0.00	0.
1.02	11.45	143	0.00	0.00	0.00	0.	1.04	1.15	293	0.00	0.00	0.00	0.
1.02	12.00	144	0.00	0.00	0.00	0.	1.04	1.30	294	0.00	0.00	0.00	0.
1.02	12.15	145	0.00	0.00	0.00	0.	1.04	1.45	295	0.00	0.00	0.00	0.
1.02	12.30	146	0.00	0.00	0.00	0.	1.04	2.00	296	0.00	0.00	0.00	0.
1.02	12.45	147	0.00	0.00	0.00	0.	1.04	2.15	297	0.00	0.00	0.00	0.
1.02	13.00	148	0.00	0.00	0.00	0.	1.04	2.30	298	0.00	0.00	0.00	0.
1.02	13.15	149	0.00	0.00	0.00	0.	1.04	2.45	299	0.00	0.00	0.00	0.
1.02	13.30	150	0.00	0.00	0.00	0.	1.04	3.00	300	0.00	0.00	0.00	0.

SUM	31.72	29.28	2.44	545765.
	(806.)	(744.)	(62.)	(15454.34)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29279.	17175.	5685.	1895.	545765.
CMS	829.	486.	161.	54.	15458.
INCHES		21.92	29.02	29.02	29.02
MM		556.66	737.03	737.04	737.04
AC-FT		8516.	11276.	11276.	11276.
THOUS CU M		10505.	13909.	13909.	13909.

HYDROGRAPH AT STA 11 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	21.	103.	303.	631.	1040.
1482.	1892.	2244.	2521.	2737.	2903.	3029.	3128.	3198.	3244.
3263.	3314.	3338.	3356.	3370.	3382.	3390.	3397.	3403.	3460.
3663.	8142.	8904.	5848.	6898.	7939.	8932.	9827.	10678.	11517.
12359.	13168.	14017.	15536.	18284.	22381.	26295.	28617.	29279.	28045.
26008.	23505.	21327.	19334.	17419.	15404.	12999.	10869.	8881.	7094.
5631.	4668.	3598.	2923.	2397.	1994.	1731.	1525.	1352.	1218.
1098.	1005.	930.	886.	855.	831.	811.	789.	757.	709.
617.	521.	421.	330.	253.	193.	147.	111.	83.	62.
48.	36.	29.	22.	17.	13.	10.	8.	6.	4.
3.	2.	1.	1.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29279.	17175.	5685.	1895.	545765.
CMS	829.	486.	161.	54.	15454.
INCHES		21.92	29.02	29.02	29.02
MM		556.66	737.03	737.04	737.04
AC-FT		8516.	11276.	11276.	11276.
THOUS CU M		10505.	13909.	13909.	13909.

HYDROGRAPH AT STA 11 FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	11.	52.	151.	315.	520.
741.	946.	1122.	1260.	1368.	1452.	1515.	1564.	1597.	1622.
1642.	1657.	1669.	1678.	1685.	1691.	1695.	1698.	1701.	1730.
1832.	2071.	2452.	2924.	3449.	3970.	4466.	4914.	5339.	5759.
6180.	6584.	7008.	7768.	9142.	11191.	13148.	14309.	14640.	14022.
13004.	11753.	10664.	9667.	8709.	7702.	6500.	5434.	4440.	3547.
2815.	2234.	1797.	1462.	1198.	997.	865.	762.	676.	607.
549.	502.	465.	443.	428.	415.	405.	395.	379.	350.
309.	260.	210.	165.	127.	97.	73.	55.	42.	31.
24.	19.	14.	11.	9.	7.	5.	4.	3.	2.
2.	1.	1.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME

CFS	14600.	4517.	2842.	948.	272882.	
CMS	415.	243.	80.	27.	7727.	
INCHES		10,96	14,51	14,51	14,51	
MM		278,33	368,52	368,52	368,52	
AC-FT		4258.	5638.	5638.	5638.	
THOUS CU M		5252.	6954.	6954.	6954.	

SUMMARY OF PMF AND ONE-HALF PMF FLOOD ROUTING

AND

DAM SAFETY ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO APPLIED TO FLOWS	
				RATIO 1 1.00	RATIO 2 .50
HYDROGRAPH AT	11	7.29 (18.88)	1	29279. (829.09)	14640. (414.55)
ROUTED TO	11	7.29 (18.88)	1	26557. (752.01)	12244. (346.67)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	670.00	670.00	680.00
STORAGE	1703.	1703.	3248.
OUTFLOW	0.	0.	17000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	681.91	1.91	3681.	26557.	2.75	17.75	0.00
.50	678.14	0.00	2961.	12243.	0.00	18.00	0.00